TARSANDS DEVELOPMENT STUDY

STAGE I

VOLUME I

TEXT MATERIAL

SUBMITTED BY

TECHMAN ENGINEERING LTD.

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of the Canada Centre for Mineral and Energy Technology,
Energy, Mines and Resources, Canada

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Their free and full participation contributed in a major way to the success of Stage I of the study: the assumptions, conclusions and recommendations documented herein, however, are the sole responsibility of Techman Engineering Ltd. and are not represented to be a reflection of the opinions of individual members of the Concept Development Team, nor of their companies or agencies.

In describing the cases examined in this study, reference is made to certain proprietary processes in extraction and upgrading and to specific equipment items in mining. These references are illustrative and do not represent an endorsement of particular equipment items or manufacturers, nor do they reflect an opinion on the relative suitability of processes in certain applications since Stage I did not include process optimization or any detailed comparative evaluation of competing processes. Processes were selected primarily on the basis of proven technology.

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1.0 INTRODUCTION

As a result of the long development period, the very large capital requirements, and the associated need to put in place large multi-owner consortia, the mega-project approach to developing surface mineable tarsands deposits may not be practical in the near term future. All potential owner/investors have cash flow and financing problems in the current business environment and are very interested in having examined smaller scale alternatives based on the modular approach, with expandability features.

Techman Engineering Ltd. were commissioned by the Federal Government to manage a tarsands development study that would examine alternative technologies, scale, ownership and structure; taking into consideration other factors that would impact on the economic viability of a project, with particular emphasis on mining. A rather unique approach to the study was developed, whereby selected owner and potential owner companies were afforded the opportunity to contribute their expertise and knowledge to the study. To that end, a Concept Development Team was established that initially had the task of identifying the alternate schemes to be examined, and establishing the criteria to be used in evaluating these schemes.

Upon completion of this initial task, the Concept Development Team undertook to review, criticize and comment on the technical and other evaluation work performed by Techman Engineering Ltd. The membership of the Concept Development Team included representatives from six owner and potential owner companies, the Energy Resources Conservation Board, (ERCB), outside consultants and Techman Engineering Ltd.

Stage I, the subject of this report, is a screening level evaluation of selected potential development cases to obtain directional information on the separate and combined effects of size, technology, ownership and structure. Stage II is anticipated to be a detailed evaluation based on the data and directional information from Stage I, culminating in a final selection of the best cases.

The Concept Development Team received and accepted the specific objectives that had been developed for Stage I. Additionally they developed a general objective that would be applicable to the total study and serve to bring the Stage I objectives and methodology into an understandable focus.

1.1 Study Objectives

1.1.1 General

To define one or more surface mineable tarsands development schemes, addressing considerations of alternative technologies, scale, ownership and structure, government policy and practice, regional and industrial benefits, national benefits, etc., that in the anticipated operating and market environment are economically viable, financeable, acceptable from a risk standpoint and manageable in scope.

A secondary objective is to identify potential technology enhancements that would significantly improve the best schemes and develop plans to bring the identified potential technology enhancements to a level of commercial and industry acceptability.

1.1.2 Stage I Specific Objectives

- to identify the characterizing features and constraints of a "mega-project" and "modular-project" approach to the development of a tarsands property. To document, for the mega-project, the significant parameters such as capital cost per daily stream barrel, total cost, cash flow profile, environmental considerations, available technology and any other significant descriptive parameters;

- to identify the economic, operational and technological criteria for a modular scale project and state these in the form of absolute and desirable requirements;

- to identify probable schemes for examination, such as a 2.4k m^3/CD (15,000 BPCD) production module, outline a development scenario, including preliminary budgets and schedules, and to test the schemes versus the criteria previously established. The operations to be examined will primarily be those within the mine fence although energy and operations integration with downstream units will be taken into account. The analysis will typically demonstrate the effects of size, financing, and capital investment arragements (for example, cost of service or sale of product) on all cash movements throughout the life of the plant;

- to select surface mineable tarsand development schemes that demonstrate a probability of success, and develop a study program for detailed evaluation and ranking of the selected schemes; and

- to prepare presentation material to display the preliminary conclusion and proposed future study program to audiences selected by the government.

1.2 Background Information

1.2.1 History of Tarsands Development

Interest in developing tarsands deposits goes back to the late 1800's when exploration was conducted on the premise that a reservoir of pure petroleum lay beneath the tarsands. Since that time, the potential of the tarsands has resulted in countless experiments, several pilot projects and two large-scale commercial surface mining operations.

The International Bitumen Company was established in 1927 and developed the first commercial tarsands operation at Bitumount, north of Fort MacKay. Its owner, R.C. Fitzsimmons, mined the tarsands and using a hot water extraction process was able to produce specification asphalt and fuel oil. Despite a number of financial and technical difficulties, he produced, in 1938, 2,500 barrels of specification asphalt and 2,000 barrels of fuel oil (McRory 1982).

At about the same time, Max Ball secured a lease on the federal government's Horse River Reserve, southwest of Fort McMurray, and formed Canadian Northern Oil Sands Products Limited. In 1931, the company became known as Abasands Oil Limited and obtained agreements with both governments to operate a plant capable of handling not less than 250 tons per day of sand. Construction started in 1935 and the plant was completed almost on schedule towards the end of 1936. Using a version of the hot water extraction method the plant produced a type of diesel oil which was pipelined to waterways for shipment to the mining camps on Lake Athabasca.

Unfortunately, after four years of successful operation, a fire destroyed the entire facility. By the middle of 1941, the plant had been rebuilt but a series of further setbacks forced Ball to abandon the operation. In 1943, the Abasand operation was taken over by the federal government as a test plant. A second fire, in 1945, destroyed the entire facility once again and no attempt was made to rebuild.

Commercial operations at the Bitumount facility ceased in 1942, and the plant was operated by the Alberta government for a number of years as an experimental extraction facility. The Alberta Research Council, under Dr. K.A. Clark, continued the work started by the Council in 1919 looking at ways to separate the bitumen from the tarsand. The plant proved that the hot water process was technically feasible, but it was not on a commercial scale and the economics of tarsands development remained doubtful.

The year 1950 brought on a flurry of interest when the Blair Report stated the economic attractiveness of tarsands development on the scale of 3.2k m^3/CD (20,000 BPCD) of synthetic crude production, or more. Oil companies began to realize that if planned on a large enough scale, the extraction and enhancement of bitumen from the tarsands would become economical as supplies of conventional oil began to run short. The first of these companies was Cities Service Athabasca Inc. which built a

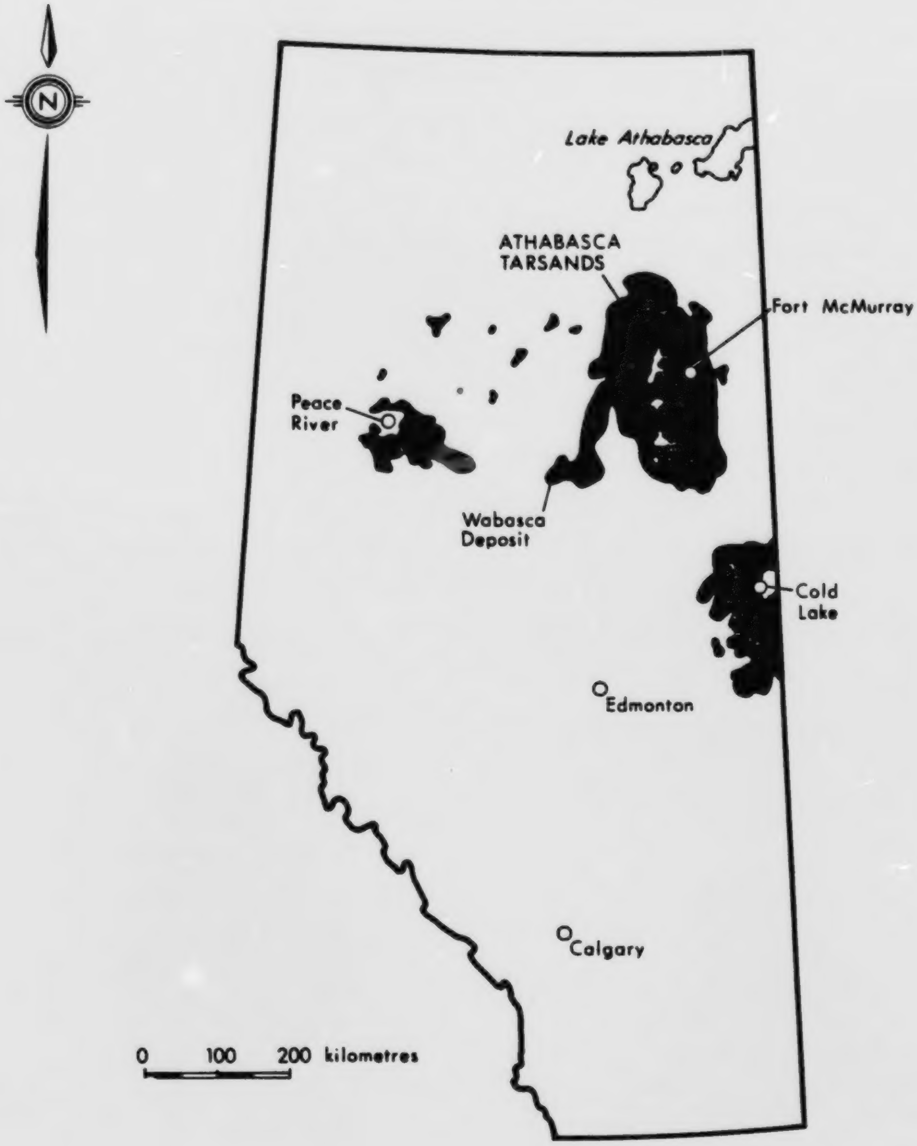
1,000 barrel per calendar day (BPCD) pilot plant at Mildred Lake, north of Fort McMurray. Experimental work on mining, material handling and extraction was carried out at the plant until 1964.

After many years of planning and research there are two large-scale commercial plants; the Suncor Inc. (formerly Great Canadian Oil Sands) plant commenced operations in 1967 and the Syncrude Canada Ltd. plant which commenced operating in 1978. Suncor was the first "mega" operation with an initial capacity of 7.2k m^3/CD (45,000 BPCD) of synthetic crude. Syncrude Canada Ltd. has an ultimate debottleneck capacity of 17.3k m^3/CD (109,000 BPCD) of synthetic crude.

The current interest in tarsands development is not limited to the Suncor Inc.'s and Syncrude Canada Ltd.'s surface mining operations. Several pilot projects are investigating the feasibility of recovering the bitumen from the tarsands deposits by a number of in-situ recovery methods, including steam stimulation. The Alberta Oil Sands Technology and Research Authority (AOSTRA) is sponsoring a number of projects involving both in-situ and surface mining methods. These projects, as well as ongoing experimentation and development of new mining, extraction and upgrading methods, are designed to make the recovery and enhancement of bitumen more efficient and economical.

1.2.2 Location and Physical Description

The Athabasca tarsands deposit is located 400 km northeast of Edmonton (Map 1.2-1). This is the largest body of tarsands in Alberta and covers an area of approximately 3.1 million hectares. It is estimated that there are 137 x 10^9 m^3 (862,000 million barrels) of bitumen in this area (McRory 1982) with 10 percent of that amount considered recoverable by current surface mining techniques. The definition of a surface mineable deposit is any deposit of tarsand which has an approximate strip ratio of 1:1, or less. An orebody not greater than 90 m in


Lake Athabasca
ATHABASCA TARSANDS
Fort McMurray
Peace River
Wabasca Deposit
Cold Lake
Edmonton
Calgary
0 100 200 kilometres
N

TARSANDS DEPOSITS IN ALBERTA

MAP 1.2 - 1

thickness, with a similar overburden thickness, can be mined with current surface mining techniques.

The Athabasca region is 60 percent covered by muskeg while the rest is sand or low quality soil. Softwoods such as white spruce, balsam fir and jackpine are sparsely distributed throughout the region.

The climate is subarctic and is an important consideration for any development project as the tarsands go from very sticky in the summer to rock hard in the winter months. Annual precipitation is about 46 cm over the region.

There is only one large settlement or city in the Athabasca region. Fort McMurray, with a population near 30,000 has grown to its present size largely due to tarsands development in the area.

2.0 STUDY APPROACH

2.1 Introduction

To meet the objectives for Stage I, as described in Section 1.0, a study group was formed, structured in accordance with the attached organization chart (Figure 2.1-1). The study group's activities, spanning a period of approximately three months, were undertaken using a task format. The specific tasks were described in detail as the "Statement of Work" which formed a part of the contract, and they can be summarized as follows:

Task 1

Assemble and mobilize the Concept Development Team and Techman Engineering Ltd. personnel to perform the Stage I work.

Task 2

Describe a traditional "mega-project" by identifying and quantifying significant characterizing parameters including economic, environmental and technological factors.

Task 3

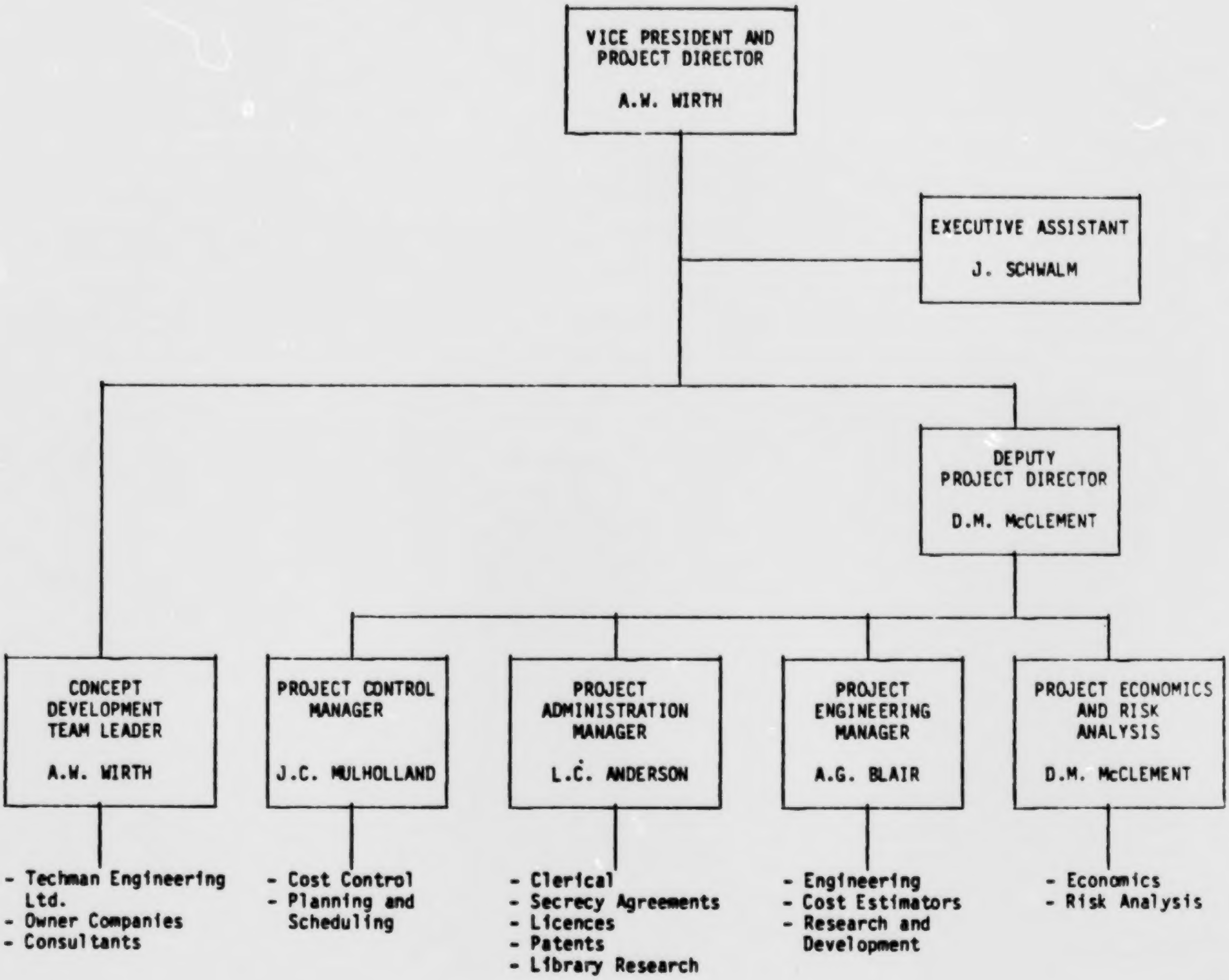
List "Musts" and "Wants"; the factors which must be present or are desireable to characterize a successful, viable, alternative to the traditional tarsands mega-project.

Task 4

Identify alternative process combinations comprising mining, extraction, and upgrading components that appear to have high probability of success. List for each those characteristics and parameters required to make a preliminary economic and technical evaluation.

Figure 2.1-1

Organization Chart for the Tarsands Development Study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- Planning and Scheduling
- Clerical
- Secrecy Agreements
- Licences
- Patents
- Library Research
- Engineering
- Cost Estimators
- Research and Development
- Economics
- Risk Analysis

Task 5

Prepare estimates of preliminary costs for identified development cases (as selected in Task 4) using data from the literature, licensor data, historic cost data, and other cost information available in the public domain.

Task 6

Prepare preliminary development schedules for each case and integrate the schedule with the estimating data to obtain pro-forma cash profiles.

Task 7

Make preliminary evaluation of alternatives by using cost and schedule data and other descriptive operating and performance data as outlined in Task 4. Test each of the proposed alternate development cases against the "Musts" and "Wants" identified in Task 3 and rank the cases in accordance with this analysis.

Task 8

Select most probable alternatives for detailed evaluation by reviewing the provisionally selected alternate cases. Based on indicated success versus the viability criteria, and considering technological risk, select those cases to be evaluated in detail in Stage II of this project. Cases selected at this time will probably include those feasible with present technology as well as those carrying a technological risk that may be justified by potentially superior performance, and schemes requiring pilot or demonstration plant work to commercially demonstrate the technology.

Task 9

Develop program for detailed evaluation, including the specific objectives and work statement for a study plan to evaluate the alternate cases selected. Determine the specific methodology to be used in subsequent stages, including the required accuracy of estimates and other data. Develop the engineering manpower, cost estimates and schedule for Stage II activity.

Task 10

Presentation of results for the Stage I work (Tasks 1 to 9) to be displayed in a final report (i.e, this document) and in the form of presentations to audiences selected by the government.

Task 11

Study management; those activities necessary for the planning of the Stage I work and ensuring that the program is completed on time and within budget.

2.2 Concept Development Team

The Concept Development Team was comprised of experienced personnel from within the Loram Group, senior people from operating companies which have significant lease holdings in surface mineable tarsands areas of the Athabasca, personnel formerly holding key positions in Alsands Energy Ltd., and representatives seconded from engineering and consulting companies having very specialized expertise in synthetic crude recovery and production from tarsands. A list of the team members, their companies and positions is included in the "Acknowledgement" section of this report.

The role of the CDT was to:

- modify (if necessary) and endorse the objectives and methodology of Stage I;

- modify (if necessary) and endorse the mega-project description (Task 2) prepared by Techman Engineering Ltd;

- develop "Musts", "Wants" and identify alternate cases for evaluation (Tasks 3 and 4); and

- function in an advisory capacity to overview Techman Engineering Ltd.'s activities during the balance of the Stage I work.

The Concept Development Team convened for 12 working days over a period of two months. The details of the Concept Development Team deliberations are included in the minutes (Appendix A). The results of this work can be found in Section 4.0 of this report.

2.3 Techman Engineering Ltd.

Techman Engineering Ltd. provided the overall management of the work and the office facilities and resources to execute the study. Techman Engineering Ltd.'s role in Stage I can be summarized:

- overall study management;
- prepare a characterization of a typical mega project (Task 2);
- participate in the Concept Development Team meetings;
- complete a preliminary screening of the cases identified by the Concept Development Team and do a technical/financial analysis of the selected nine cases (Tasks 5, 6, 7 and 8);
- develop a program for Stage II (Task 9); and
- prepare the final report (Task 10).

To fulfill the role described above, Techman Engineering Ltd. formed a study group, basically structured in accordance with the attached organization chart (Figure 2.1-1). This group was comprised of specialists covering a wide range of capabilities, all having expertise in tarsands and related work, including mining, extraction, upgrading, utilities, other engineering disciplines, estimators, planners, geologists, environmentalists, economists and socio-economists.

The major activities performed by Techman Engineering Ltd. included conceptual mine design, development of schematics and flow diagrams for selected cases, energy and mass balances, development of a financial model, and an analysis and description of cases (including the mega-project). The technical and financial analysis of the cases was accomplished by the Kepner-Tregoe decision analysis procedure. The results of this work are further described in detail in Section 4.0. The quality of data available in Stage I allowed for preliminary conclusions only to be made. The results, therefore, should not be construed as anything but directional.

3.0 MEGA-PROJECT DESCRIPTION

3.1 Introduction

3.1.1 Objectives

The objective of this section is to define what is meant by a "mega-project size surface mineable tarsands operation."

In meeting this objective, the section will:

- identify the characterizing features and constraints of a "mega-project" approach to the development of a tarsands property; and
- document the significant parameters such as capital cost per daily stream barrel, total cost, cash flow profile, environmental considerations, available technology and any other significant descriptive parameters.

3.1.2 Background Information

3.1.2.1 Location and Physical Description

The Athabasca tarsands deposit is located 400 km northeast of Edmonton, This is the largest body of tarsands in Alberta and covers an area of approximately 3.1 million hectares. It is estimated that there are 137 x 10^9 m^3 (862,000 million barrels) of bitumen in this area (McRory 1982) with only 10 percent of that amount considered recoverable by current surface mining techniques.

The definition of a surface mineable deposit is any deposit of tarsand which has an approximate strip ratio of 1:1. Orebodies not greater than 90 m in thickness, with a similar overburden thickness, can be mined with current surface mining techniques.

The Athabasca region is 60 percent covered by muskeg while the rest is sand or low quality soil. Softwoods such as white spruce, balsam fir and jackpine are sparsely distributed throughout the region.

The climate is subarctic and is an important consideration for any development project as the tarsands go from very sticky in the summer to rock hard in the winter months. Annual precipitation is about 46 cm over the region.

There is only one large settlement or city in the Athabasca region. Fort McMurray, with a population near 30,000, has grown to its present size largely due to tarsands development in the area.

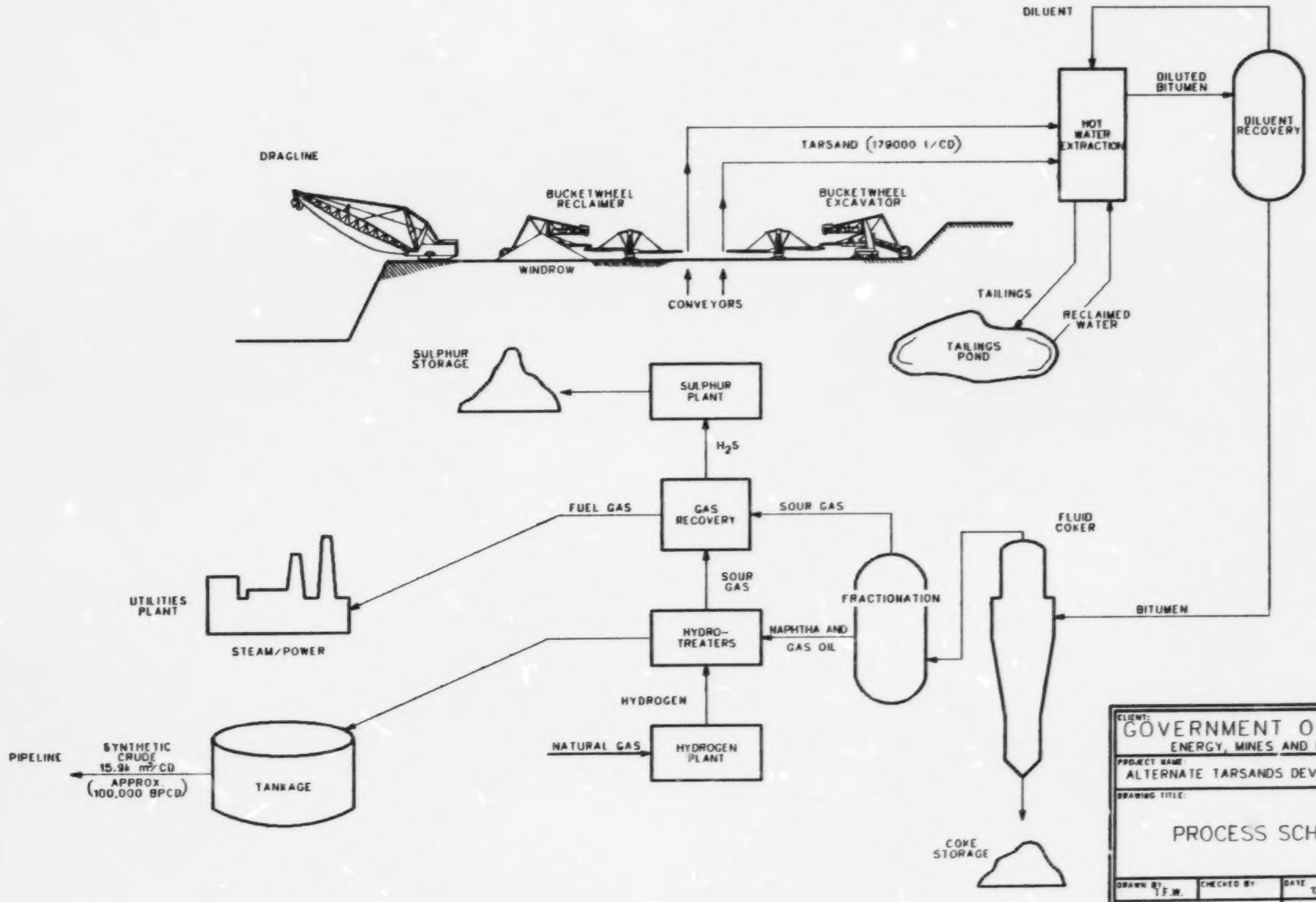
3.1.2.2 Operational Mega-Projects

There are two mega-project scale commercial plants currently in operation in the Fort McMurray area. The Suncor Inc. (formerly Great Canadian Oil Sands) plant commenced operations in 1967 and the Syncrude Canada plant which commenced operations in 1978. Suncor Inc. was the first "mega" operation with an initial calendar day (CD) capacity of 7.2k m^3/CD (45,000 BPCD). Syncrude Canada Ltd. has an ultimate debottleneck capacity of 17.3k m^3/CD (109,000 BPCD).

3.2 Facilities and Process Description

This section will describe a hypothetical integrated tarsands extraction facility in the Alberta (Athabasca) surface mineable ore reserve area. The plant facilities were sized to have the capability of producing 15.9k m^3/CD (100,000 BPCD) of synthetic crude oil after a stable and efficient operation had been achieved. The process schematic (Figure 3.2-1) identifies the major component parts of this facility. The operation of the primary facilities which cover mining, extraction and upgrading are sequential, with the mining operation supplying the mined tarsands to the extraction facilities and extraction supplying bitumen to the upgrading facilities. These three primary operations are supplied with steam and electricity from the Utility Plant.

The synthetic crude oil produced from the hypothetical plant, contains no residuum and has an API Gravity of 35°. The crude oil is pipelined


DILUENT
DILUTED BITUMEN
HOT WATER EXTRACTION
DILUENT RECOVERY
TARSAND (179000 t/CD)
DRAGLINE
BUCKETWHEEL RECLAIMER
BUCKETWHEEL EXCAVATOR
WINDROW
CONVEYORS
TAILINGS
RECLAIMED WATER
TAILINGS POND
SULPHUR STORAGE
SULPHUR PLANT
H2S
FUEL GAS
GAS RECOVERY
SOUR GAS
SOUR GAS
FLUID COKER
UTILITIES PLANT
STEAM/POWER
FRACTIONATION
BITUMEN
HYDRO-TREATERS
NAPHTHA AND GAS OIL
HYDROGEN
NATURAL GAS
HYDROGEN PLANT
PIPELINE
SYNTHETIC CRUDE 15.9k m³/CD
APPROX. (100,000 BPCD)
TANKAGE
COKE STORAGE

CLIENT: GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME: ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:

PROCESS SCHEMATIC

DRAWN BY	CHECKED BY	DATE	PROJECT No.
T.F.W.		12/16/82	TM500

DRG. No.: TS5008033

FIGURE 3.2-1

to the Edmonton area where it enters existing supply systems for use in the Edmonton area refineries, or is moved east via Inter Provincial Pipeline or west via Trans Mountain Pipeline, as a substitute for light sweet Western crude oil.

3.2.1 Minesite

3.2.1.1 Mining

Tarsand mining involves the excavation of a large volume of material, which is generally difficult to handle (abrasive, hard, sticky) under unfavourable mining conditions (summer-poor trafficability on soft tar sand; winter-very cold weather, difficult maintenance, hard tarsand, etc.).

One bank cubic metre (BCM) of tarsand will yield approximately 0.21 m^3 (1.34 barrels) of bitumen (extraction by Clark Hot Water Process), which in turn is upgraded to 0.18 m^3 (1.16 barrels) of synthetic crude as shown in Figure 3.2-2.

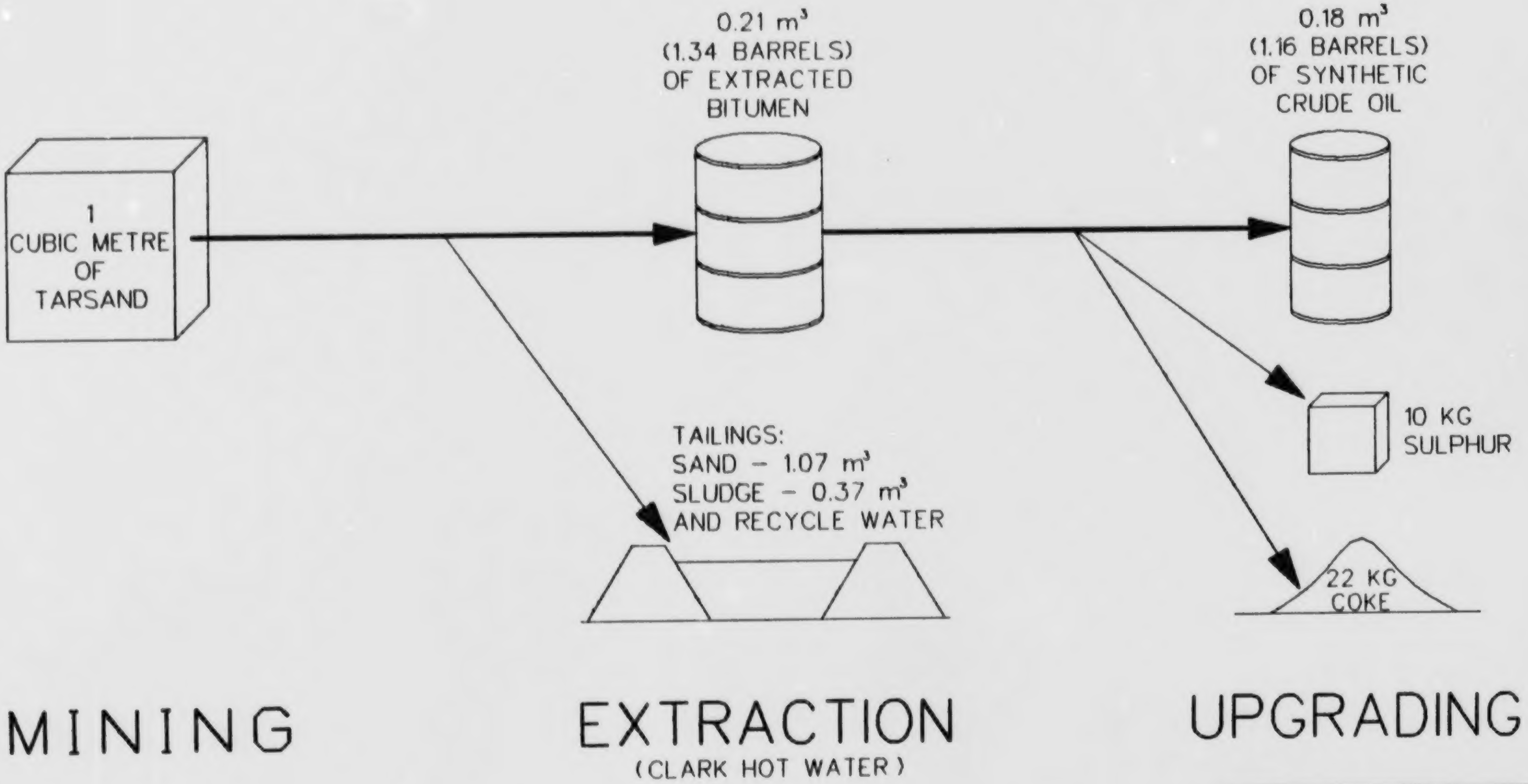
Approximate mining quantities for a 15.9k m^3/CD (100,000 BPCD) mine operating for 25 years would be:

plant feed (tar sand)	800 x 10^6 BCM
overburden (incl. top reject)	340 x 10^6 BCM
centre reject	150 x 10^6 BCM

Based on an assumed average bitumen content of 11.5 percent by weight, approximately 86,000 BCM per calendar day of tarsands is mined and moved to the Extraction Plant.

The approximate areal extent (in hectares) for such an operation would be:

ultimate pit area	2600
plant site	400


1
CUBIC METRE
OF
TARSAND
0.21 m^3
(1.34 BARRELS)
OF EXTRACTED
BITUMEN
0.18 m^3
(1.16 BARRELS)
OF SYNTHETIC
CRUDE OIL
TAILINGS:
SAND – 1.07 m^3
SLUDGE – 0.37 m^3
AND RECYCLE WATER
10 KG
SULPHUR
22 KG
COKE
MINING
EXTRACTION
(CLARK HOT WATER)
UPGRADING

GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

ALTERNATE TARSANDS DEVELOPMENT STUDY

TARSANDS PRODUCTS
AND BYPRODUCTS

R.W.S.
J.H.
DEC. 1982
TM500
TARPRODUCT
FIGURE 3.2-2

waste dumps (overburden, reject)	700
tailings pond	1600

In addition, temporary and/or permanent muskeg dumps will be required, which could be of considerable areal extent. A settling pond, possibly off-lease, will be required for effluent from muskeg and overburden dewatering, and if of acceptable quality, also for aquifer depressurization effluent.

A typical mining sequence for a multi-bench operation is as follows:

1. Clearing (bulldozing of trees and shrubs)
   - (one year gap)
2. Burning of windrowed wood
3. Muskeg ditching (muskeg dewatering)
   - (two year gap)
4. Muskeg removal (winter)
5. Overburden ditching (trafficability)
6. Overburden dewatering (deep ditches, sumps and wells)
   - (one year gap)
7. Overburden stripping
8. Aquifer depressurization (if required)
   - (two year gap)
9. Upper bench tarsand mining
   - (two year gap)
10. Lower bench tarsand mining

Preproduction activities in the mine area would start some five years before the first cubic metre of plant feed (tarsand) is delivered into the Extraction Plant. A sufficiently large area is cleared and muskeg is ditched. When drained, muskeg is removed and overburden prestripping initiated, usually two years before the plant start-up.

For a multi-bench operation, a certain initial tarsand bench configuration has to be excavated to facilitate sufficient plant feed production during the first two or three years of operation. Preproduction activities are usually handled by a contractor.

Major mining excavators include draglines and/or bucketwheel excavators (reclaimers), as well as hydraulic shovels. Mined material (ore or waste) is transported by trucks and/or belt conveyors to extraction or to waste dumps, which could be located out of pit or in-pit. If a conveyor is used to transport overburden and/or centre reject, a tripper car and spreader have to be employed to remove the material off the belt and place it in an appropriate location within a waste dump. Other mine activities include construction of haul roads, conveyor pads, dragline pads, starter dyke, dykes for various effluent ponds, etc.

3.2.1.2 **Tailings Disposal**

Tailings left after extraction of bitumen from tarsand must be stored in the general area, and therefore, the tailings disposal is considered an integral part of mine planning. Approximate tailings quantities from a 15.9k m^3/CD (100,000 BPCD) operation (25 years) would be:

sand	860×10^6 m^3
sludge	300×10^6 m^3
recycle water	approx. three metre deep layer of clarified water left on tailings pond(s)

The tailings disposal system involves hydraulic transportation of sand and fines (forming sludge) to a permanent or temporary impoundment via five 610 mm (24 ins.) pipelines. Included also is a reclaimed water system integrated with heat recovery systems in utilities and upgrading.

To minimize environmental impact, sludge is permanently stored in one of the mined-out pits, minimizing the sludge pond surface area. In-pit tailings disposal cannot be commenced until the mining benches have progressed sufficiently to allow for construction of an in-pit dyke, which might be in the ninth year of tarsand mining. Ultimately, the out-of-pit tailings pond will be filled with tailings sand and sludge pumped to the in-pit sludge pond. An alternative option would be to store sludge in the out-of-pit tailings pond (i.e. sludge pond) while disposing of tailings sand into the mined-out pit after Year 9.

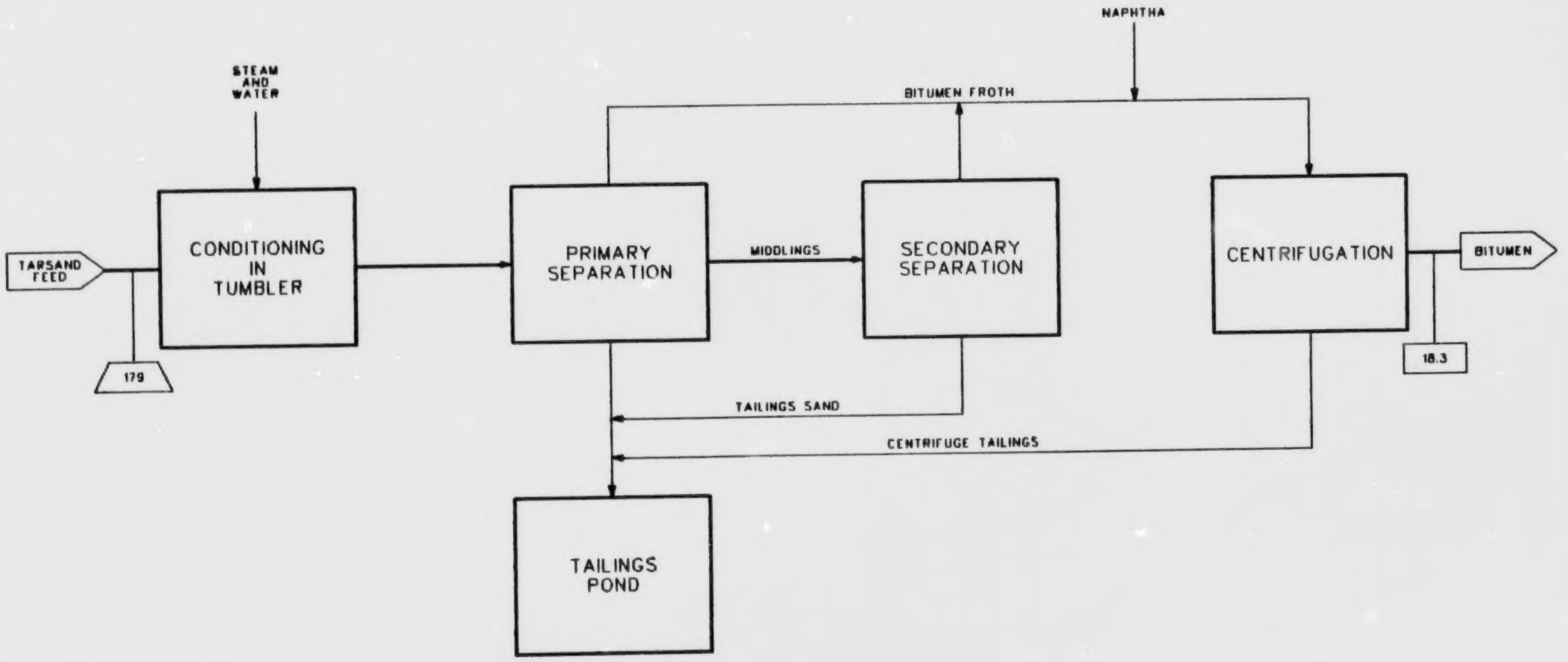
Support facilities for mining include repair and maintenance shops, yard laydown, warehousing operations centre, fueling systems and support equipment fleets.

3.2.2 Extraction Facilities

The prime function of the extraction facilities is to recover the bitumen from the tarsands material. The conventional recovery technique used is the Clark Hot Water Process. The basic steps in the hot water process involve feed conditioning, primary separation of the bitumen froth, secondary extraction of the bitumen from the middlings and final removal of the mineral matter and water by centrifugation (Figure 3.2-3). Facilities include:

- feed surge system to even out production rates between the mine and Extraction Plant;
- steam/hot water extraction system using rotating tumblers, gravity and centrifugal separation;
- rejects handling system;
- caustic soda handling and injection system;
- process water and steam supply system; and
- naphtha dilution system

The extraction facility is constructed with four trains of equipment in the feed, primary separation and froth treatment systems.


NAPHTHA
STEAM AND WATER
BITUMEN FROTH
TARSAND FEED
CONDITIONING IN TUMBLER
PRIMARY SEPARATION
MIDDLINGS
SECONDARY SEPARATION
CENTRIFUGATION
BITUMEN
179
18.3
TAILINGS SAND
CENTRIFUGE TAILINGS
TAILINGS POND

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
SCHEMATIC REPRESENTATION
OF THE HOT WATER
EXTRACTION PROCESS

DRAWN BY T.F.W.
CHECKED BY
DATE 12/16/82
PROJECT No.: TM500
DWG No. TS5008032
FIGURE 3.2-3

3.2.3 Upgrading Facilities

The upgrading portion of a tarsands plant converts the extracted bitumen to the quality of a conventional crude oil suitable for further processing by oil refineries. The upgrading plant is made up of nine stand-alone process units which are designed to recover the diluent for re-use, chemically restructure the bitumen to more valuable products, hydrogenate the products to improve stability and product quality and to recover by-products, such as sulphur, for environmental reasons. The nine process units include:

- a diluent recovery system;
- a primary conversion (coking) process;
- a gas recovery system;
- naphtha hydrotreaters;
- gas oil hydrotreaters;
- a hydrogen production system;
- a nitrogen generation plant;
- sour water handling;
- an amine treating system;
- sulphur recovery; and
- a tail gas clean-up system.

The upgrading facility is divided into two parallel trains thereby doubling the number of units in the system.

The Fluid Coking process is used as the primary conversion process to convert the bitumen to a residuum free product. The produced coke is not utilized and is stored on the site. The naphtha and distillate products from the coking operations are hydrotreated (secondary upgrading) and blended to produce a low sulphur reconstituted crude oil capable of being processed by existing refineries. The recovered sulphur is stockpiled.

Large energy transfers occur between the upgrading operation, where fuel gas and waste heat are produced, to the extraction facilities which require large volumes of hot water and steam.

To maintain a synthetic crude oil production rate of 15.9k m^3/CD (100,000 BPCD) the upgrading plant must receive approximately 18.3k m^3/CD (115,000 BPCD) of extracted bitumen feed.

The upgrading portion of a tarsands plant can be compared to the process units associated with two basic 8k m^3/CD (50,000 BPCD) oil refineries processing conventional crude oil.

3.2.4 Utilities

In addition to the requisite mining and refining facilities, an energy supply system integrated both physically and technically into the production process is an important feature of a tarsands plant (Figure 3.2-4). The utilities are housed in one building, with the exception of a high voltage substation, and include electrical power, steam, boiler feed water and compressed air.

The Utility Plant concept is based on principles of providing self-sufficiency of energy within the complex, maximum heat recovery consistent with plant operating flexibility and minimum impact on the environment from atmospheric emissions and waste discharge. In being self-sufficient, the steam and electrical systems in the Utility Plant have to cater to a large number of operating modes which require a widely, independent and constantly varying load of steam and electricity. In order to meet the varying combinations of steam and electricity needs, back pressure turbine-generators and condensing/extraction steam turbine-generators are installed.

The Utility Plant consists of a combined cycle operation. The gas turbines and steam generators are designed to be fired with sweet gas which is generated in the upgrading facilities. The sweet gas is supplemented with natural gas as required under certain operating conditions. Gas oil from the upgrading can also be fired in the boilers under emergency conditions.

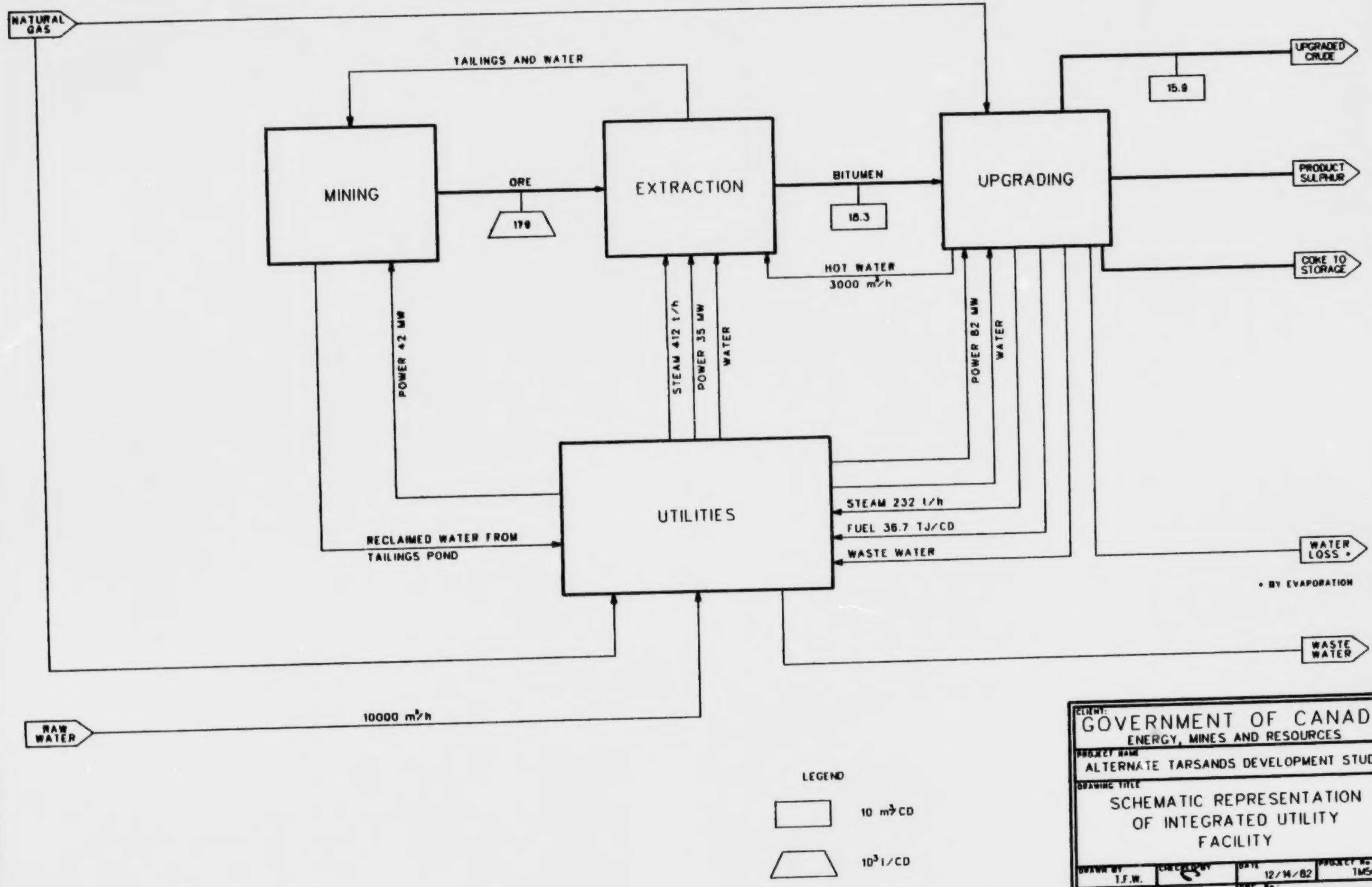
The tarsands complex requires large quantities of low pressure steam for the extraction of bitumen from the tarsands and electric power for the operation of the mining, bitumen extraction and upgrading facilities. In order to meet these demands the Utility Plant has the capacity to produce 1150 tonnes of steam per hour and the capacity to generate 300 MW of power at 72,000 volts. Since a substantial portion of the steam is required as live steam for the process, the Utility Plant includes a large water treatment plant for make-up purposes. The water treatment plant consists of a two stage clarifier/sand filter pretreatment and a demineralization system. The demineralization system consists of six ion-exchange trains, six organic screen units and required ancillaries and storage. Next to tarsand, water is the most important ingredient used in the hot water extraction process, as well as in the generation of power for the mining operation. Using conventional production techniques, approximately 2.8 m^3/sec of raw water would be needed to meet the plants needs.

There is a tie to the Alberta Grid through a 240-KV line for back-up electrical supply on an interruptible basis.

The Utility Plant also includes a compressed air system which supplies instrument and plant air requirements to upgrading and offplots.

3.2.5 General and Off-Plot Areas

The general and off-plot areas for the hypothetical mega-project consist of all site work and facilities within, and including, the fenced area which is not part of the major processing areas of extraction, upgrading and utilities generation. Plant support systems, such as water supply and treatment, firewater systems, sewer systems, waste treatment, steam and power distribution systems, roads, tankage, plant


NATURAL GAS
TAILINGS AND WATER
MINING
ORE
179
EXTRACTION
BITUMEN
18.3
UPGRADING
15.9
UPGRADED CRUDE
PRODUCT SULPHUR
COKE TO STORAGE
HOT WATER 3000 m³/h
POWER 42 MW
STEAM 412 t/h
POWER 35 MW
WATER
POWER 82 MW
WATER
UTILITIES
RECLAIMED WATER FROM TAILINGS POND
STEAM 232 t/h
FUEL 36.7 TJ/CD
WASTE WATER
WATER LOSS *
* BY EVAPORATION
WASTE WATER
RAW WATER
10000 m³/h
LEGEND
10 m³/CD
10³ t/CD

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
SCHEMATIC REPRESENTATION
OF INTEGRATED UTILITY
FACILITY

DRAWN BY	CHECKED BY	DATE	PROJECT No.:
T.F.W.		12/14/82	TM500
		DWG No.: TS5008031	

TECHMAN

FIGURE 3.2-4

lighting etc. are sized to meet the requirements of the mining, extraction, upgrading and utility plant operations. Administration, maintenance, laboratory and other plant infrastructure requirements are sized to accommodate the personnel and the equipment necessary to operate, maintain and service the plant.

The major constituents of the general and off-plot areas are described below.

3.2.5.1 Site Preparation

This includes all clearing, grubbing, water control, stripping, rough grading, finish grading and surfacing, including road works and any other civil works which are general purpose.

3.2.5.2 Tankage

Tankage for all feedstocks, intermediate surge and product storage water, effluents, byproducts and other tankage of a general nature is included here along with the required tank pads, dykes, foundations and the like.

3.2.5.3 Interconnecting Facilities

These include all elevated and grade level pipeways carrying product and service lines between all areas of the project.

3.2.5.4 Relief and Blowdown

This includes facilities from the battery limits of the plants or source areas through and including the blowdown drums, flare stacks and flare pits.

3.2.5.5 Electrical Distribution

A system provides for the reticulation of electrical energy from the public utilities point of delivery, to the utility generation facility substation and to the first substation in each of the consuming areas.

3.2.5.6 Water Supply

This includes all facilities to obtain water from either approved natural sources or municipal sources and to store, clarify and deliver to the consuming areas. Water treating and cooling facilities are part of the utility generation area.

3.2.5.7 Fire Protection

This includes all fire water loops and pumps and general purposes fire protection and fire fighting facilities and apparatus. Area specific systems are included within the user facility.

3.2.5.8 Sewage

This includes facilities for sanitary, storm, oily water and other effluents, other than extraction tailings.

3.2.5.9 General Purpose Buildings

These include the administration buildings, general maintenance and warehouse buildings, garages, guard and security buildings and the like. Area or plant specific buildings are included with the user area.

3.2.5.10 Control Centres and Communications

These include all centralized supervisory and automatic or computerized plant control systems and their connections and interfaces with plant areas along with all required buildings. Communications systems include all sourced powered, wired and wireless telephone systems as well as telex and teleprinting and modern computer facilities.

General purpose mobile and portable equipment shop tools and the like are included as required.

3.3 Characterization Parameters

The characterization parameters used to describe the hypothetical tarsands mega project are contained within the following categories:

- economics
- political considerations and risks
- environmental and regulatory considerations
- technology
- project development and execution
- plant operations
- market and product quality
- socio-economic impacts and benefits

3.3.1 Economics

Surface mineable tarsands projects are very capital intensive, requiring large capital expenditures per daily barrel of installed production capacity. Sustaining capital requirements, which covers items such as mobile equipment replacements, additional conveying equipment etc., are also high and range in the order of five to 10 percent per annum of initial capital investment. The capital costs of a tarsands mega-project are a function of the following assumptions and/or imposed requirements:

- synthetic crude quality and quantity;
- the degree of energy self-sufficiency built into the facilities;
- environmental emission standards and requirements;

- coke and/or residuum disposition;
- natural resource utilization requirements; and
- trade-offs between capital costs and future operating costs in areas of energy efficiency, operational reliability, maintenance costs, future capital costs, and other operating cost considerations.

During the start-up and operating phase of a tarsands project, the requirements are also very labor intensive and the plants are large consumers of energy. Therefore, the operating cost per barrel of production is also very high. The time required to achieve a stable and efficient operation by the two plants currently in operation has been long. Syncrude Canada Ltd. forecast that the operation will be stabilized and planned (design) annual rates of production achieved during Year 6 of the operation. There is no basis for assuming that another "mega" size plant would achieve a better performance.

The initial capital cost of the physical plant facilities (excluding infrastructure requirements outside of the lease site, i.e., pipelines, urban and residential, roads, etc.) are estimated at $55,000 to $60,000 per BPCD capacity (1982$).

The operating costs, exclusive of federal tax and provincial royalties, and return on investment, after the operation is stabilized and design annual production rates are achieved, are estimated to be approximately of $15 (1982$) per barrel of synthetic crude production. This number is judged to have an accuracy of -10 to +30 percent. Recovery of capital is also not included in this cost.

Figure 3.3-1 displays the life cycle of the hypothetical tarsands mega-project. The assumptions, with respect to the time required for the development phase, are based on the Alsands Project experience and take into account the current approval processes and the requirements thereof.

Figure 3.3.2 represents a theoretical cash flow profile for the assumed mega-project. In developing this profile, it was assumed that:

- six years would be required to achieve the planned (design) annual production rates;
- the net-back, to the operator, per barrel of synthetic crude oil production would provide him with a real rate of return on investment of 11 percent; and
- the produced synthetic crude has a priority position in the market place and will be sold as produced.

It should be noted that an accumulative negative cash flow position of 2,880 million dollars is reached before generated revenue moves the cash flow profile in a positive direction. Payback of the investment is reached in Year 18.

The elements of uncertainty (risks) that can impact on the economics of a project are:

- capital cost overrun/underrun;
- operating costs over/under forecast;
- project schedule;
- technological;
- time required to achieve design annual production rates;
- synthetic crude price;
- investor/operators net back after taxes and royalties;
- the relationship of inflation/escalation of capital and operating costs with synthetic crude price;
- sustaining capital requirements;
- stability of the regulatory and fiscal regimes;
- natural resource utilization requirements; and
- geological.

FIGURE 3.3-1

TARSANDS MEGA-PROJECT LIFE CYCLE

BASED ON CURRENT APPROVAL PROCESSES AND REQUIREMENTS

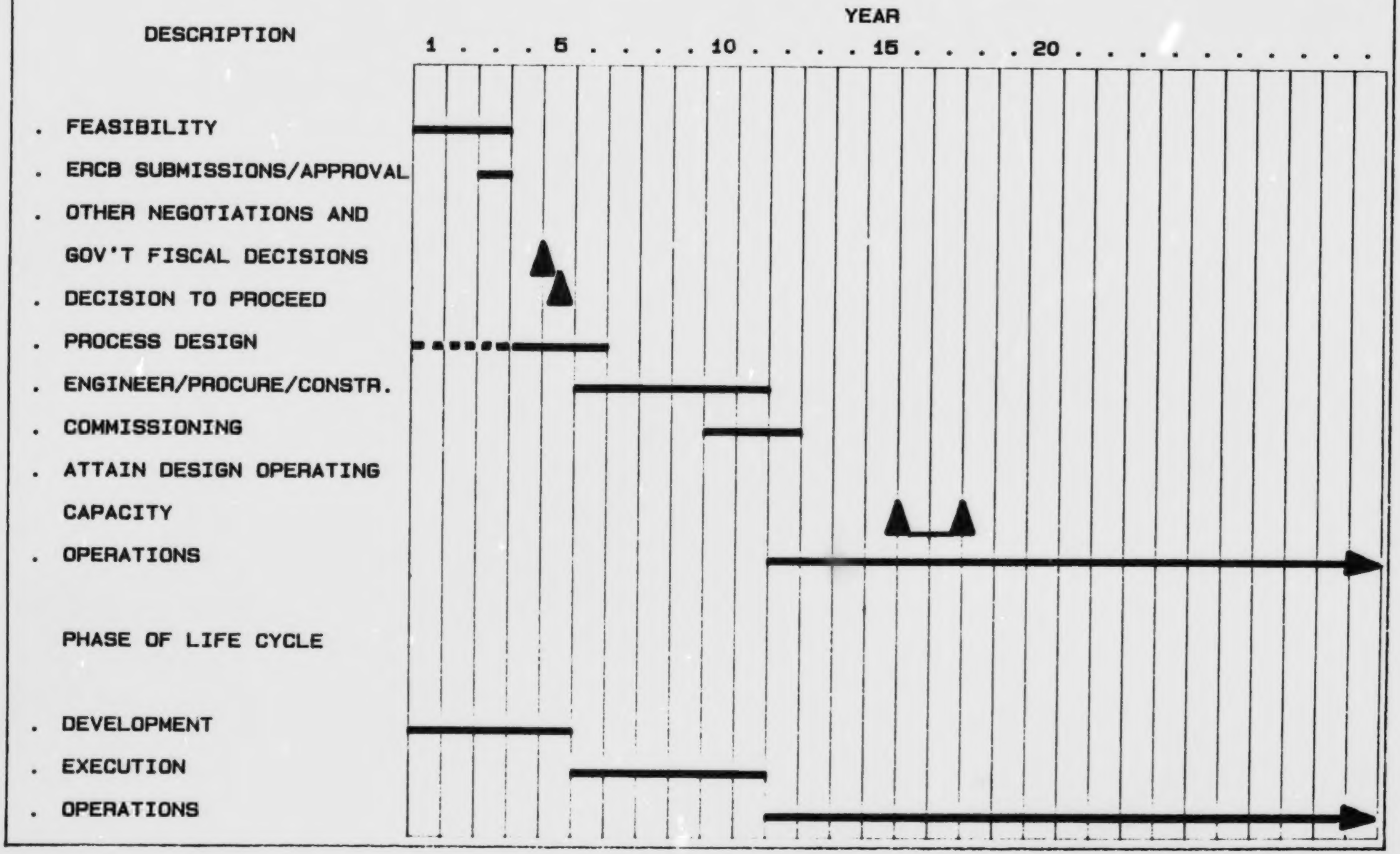
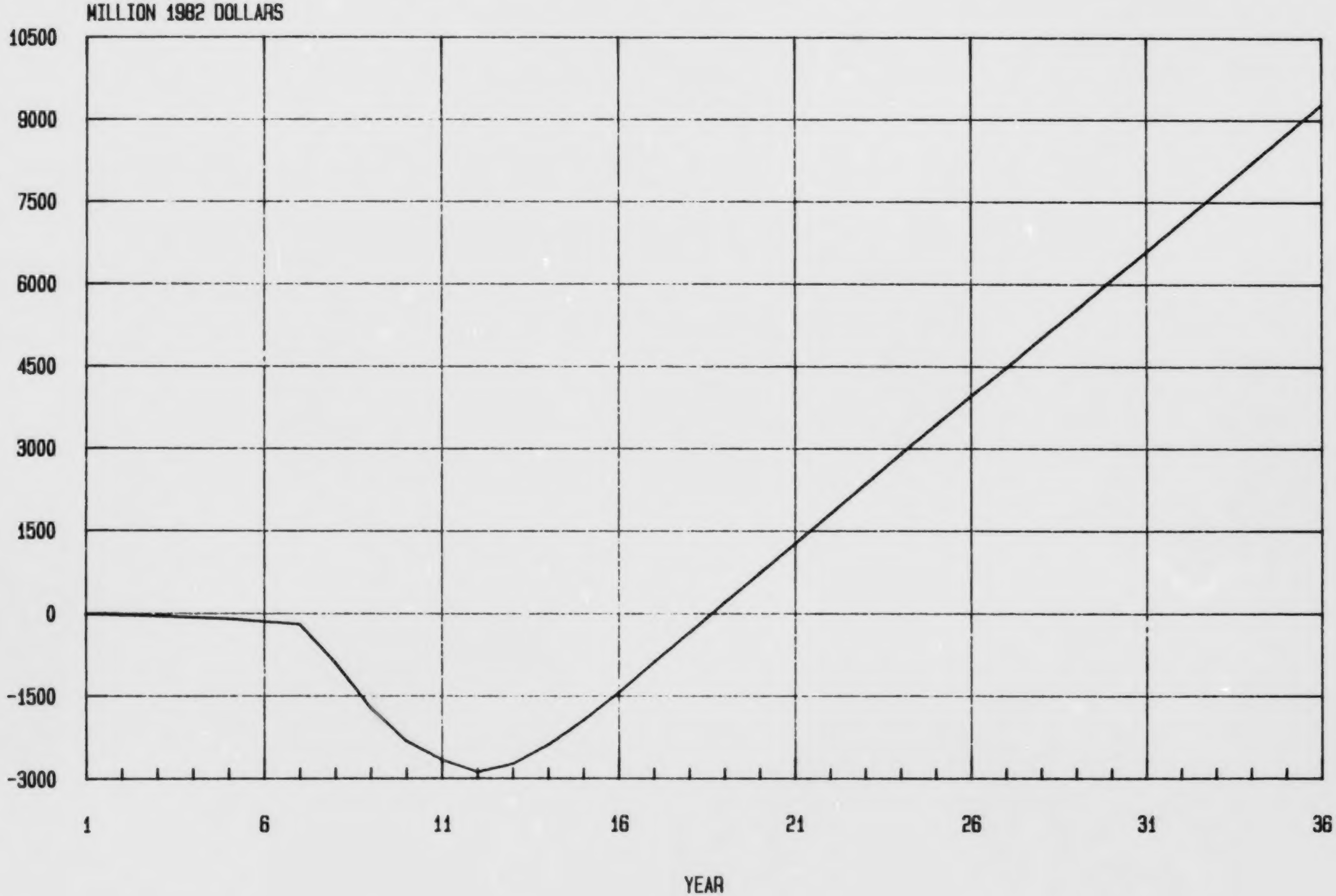


FIGURE 3.3-2

CUMULATIVE CASH FLOW PROFILE

15.9k m3/CD (100000 BPCD) SYNTHETIC CRUDE



The principle ways of financing a tarsands mega-project have been by the creation of a joint ownership consortium, which might or might not include government participation, with each owner financing their equity participation in whatever way was best for them. Parts of the plant and infrastructure requirements outside of the plant are owned by other investors or owner/operators that are not members of the joint ownership consortium.

3.3.2 Political Considerations and Risks

The fiscal and tax regimes which prevail during the 35 to 40 year economic life of the project, which includes the operational period, are controlled by the federal and provincial governments and historically have been changed during the life of the two existing plants. This constitutes a major area of uncertainty to potential investors and is the most significant political consideration and risk confronting the investor during the go/no go decision making process. Based on the Alsands Project experience, and taking into account the necessary negotiations and the current approval requirements and processes, about four years of development time is required before the commercial terms (fiscal and tax regimes) are established. During this period the potential investor(s) will have expended many millions of dollars (in excess of $100 million) without knowing if the commercial terms, which as indicated earlier, may not cover the life of the project, will result in an economically viable project.

As a result of the magnitude of capital expenditures and the resultant economic benefits related to the manufacturing of equipment and materials, engineering requirements and construction related opportunities and employment, tarsands mega-projects are very high profile and politically visible undertakings. Government departments and agencies are, therefore, disposed to use the project as a vehicle for solving some of the socio-economic problems of the region and the country. This results in the imposition of a good deal of control and influence on the non-fiscal matters during the development, execution and operational phases of the project. Cost, schedule and operational efficiencies can be adversely impacted.

Non-fiscal matters that are either controlled, or influenced by, the governments in a major way require a good deal of development time, discussions and negotiations often with both the provincial and federal governments. The objectives of the two governments are not always the same. These non-fiscal matters include:

- regional and Canadian industrial benefits;
- provincial and Canadian content;
- human resource planning;
- employment and business opportunities for people indigeneous to the area;
- offsite infrastructure considerations;
- other socio-economic impacts and benefits;
- urban and residential; and
- environmental criteria.

3.3.3 Environmental and Regulatory Considerations

Recognition of government regulatory requirements must be reflected in project planning from initial development through construction, production and post-mining reclamation periods; that is, a time frame in the order of 40 years.

Tarsands developments must comply with the Alberta Department of Environment (DOE) and the Energy Resources Conservation Board (ERCB) regulations governed by the:

- Energy Resources Conservation Act;
- Clean Water Act;
- Clean Air Act; and
- Land Surface Conservation and Reclamation Act

In the case of tarsands surface mining mega-projects, considerations of environmental impact, energy recovery and reclamation are a major influence in the development of a lease and require much attention from governments and the owner. To give some indication of the magnitude of environmental impact, a typical surface mineable tarsands mega-project would be characterized (in approximate terms):

• service disturbances:	
- overall site facilities (mine, extraction, upgrading, tailings)	10000 ha (24,700 acres)
- infrastructure (urban and utility corridor development)	5000 ha (12,350 acres)
• fresh water intake:	2.8 m^3 (37,000 IGPM)
• sulphur emissions:	60 - 90 t/d (70 - 100 TPD)
• water vapour emissions:	70×10^6 kg/d (77,000 TPD)

The time required to gather baseline data for site planning and for the preparation of an application to mine tarsands is approximately two to three years. During the course of project execution (detailed engineering and construction) a typical tarsands mega-project will require at least 200 major permits. Total permits and approvals from various government departments may be in the range of 2,000.

Permitting, monitoring and reporting requirements are ongoing during the operations phase, as well; considerable continuing participation is required on the part of the government and the owner which puts significant demands on their respective organizations.

In addition to site-specific requirements, a tarsands mega-project requires coordination with authorities in the development of supporting infrastructure such as roads, bridges, provision for a service corridor to accommodate product lines, power and water supply, natural gas and other possible services. The environmental impact of the above infrastructure is also a key consideration in a lease development.

Another characterizing feature of tarsands projects is the bitumen recovery regulations which are more stringent than other sectors of the resource industry.

3.3.4 Technology

The development and introduction of innovative process technology, within the essential production facilities of a tarsands plant, has been a very cautious and slow process. This is not because new technology is not necessary, but is primarily because:

- operators are adverse to incurring technological risk, considering the very considerable investment;

- at the large scale of development, tarsands plants are constrained to occur at long intervals, and there are, therefore, limited opportunities for innovation;

- if pilot plant or demonstration plant work is required, as is usual with new technology, this must be built into the conceptual design phase of the schedule and additional costs incurred. In 1982 dollars, it may cost an operator 100 million dollars to develop a concept to the permit stage, and if pilot plant work is additionally required, this may add a further $100 million;

- the introduction of innovative technology will have effects on adjacent, integrated units, which must be taken into account; and

- additional technical and operations experience must be incorporated into a company's data base.

In addition to the technological risk of incorporating innovative technology, the large production requirements of a mega-project require the use of the largest component equipment items available, making the plant a prototype from both the mechanical and operating viewpoint.

In complying with the regulatory process, operators have found that increasing pressures, particularly in the environmental and conservation areas, have tended to move them in the direction of higher technological risk as they considered the adoption of new, unproven processes to reduce emissions or to utilize stockpiled by-products.

The major unit operations of a typical tarsands mega-project are highly integrated for energy conservation, and a high degree of equipment redundancy is incorporated to minimize production upset and ensure reliability. The design of individual plants and systems must take these operating risks into account in a way that is not usual for the process industry.

For the mining operations of the existing mega-projects, the technology selected is based on bucketwheel excavators and conveyors. Syncrude Canada Ltd. also uses draglines, mining from an intermediate bench to form windrows of tarsand which are then reclaimed by bucketwheel excavators. Conventional wisdom is that mobile equipment, at least of the sizes available up to the time of the Syncrude Canada Ltd. design, is not capable of mining tarsands on the scale required by a mega-sized plant, and no operator has selected mobile equipment as the primary mode of mining tarsands ore. Trucks and shovels have been used in overburden removal and auxiliary mining operations.

The Clark Hot Water Process is the only proven technology for bitumen extraction at the present time. It continues to be developed and modified to improve recovery efficiencies and lessen energy requirements, but it is the basic process used at both operating plants, and was planned for the Alsands Project. The Clark Hot Water Process may fall into disfavour because of tailings disposal problems but at present the economics of the current process are favourable versus possible alternatives.

The primary upgrading technology used by both Suncor Inc. and Syncrude Canada Ltd., and which was selected for the Alsands Project, is the carbon rejection mode. Suncor Inc.'s process is Delayed Coking, described in Appendix E of this report, while Syncrude Canada Ltd. and the Alsands Project selected Fluid Coking, also described in Appendix E. Both processes produce a by-product of petroleum coke, typically with a sulphur content too high for efficient combustion without an expensive stack gas clean up. Although the coke production from a fluid coker is less than from delayed coking (and the liquid production higher), the coke tends to be more difficult to deal with due to a higher sulphur content, and is also a very refractory material. Secondary upgrading technology involves one of the many commercial applications of hydrotreating, which is a hydrogen addition step to remove sulphur and saturate cracked hydrocarbons. The production of hydrogen, required by the hydrotreaters, is typically accomplished by steam reforming of purchased natural gas, although operators have considered partial oxidation of other hydrocarbons, including coke.

After the start of operations of a tarsands facility, innovation in the modification and development of equipment, unit operations and materials is always necessary. This work usually occurs under the direction of the plant operators and leads to significant improvements in plant performance. Benefits accrue to the tarsands industry, equipment manufacturers, materials suppliers and to other associated processing industries by the demand for new and improved equipment.

3.3.5 Project Development and Execution

The project size and its resultant financial requirements are usually beyond the financial abilities or desires of a single investor and, therefore, requires participation by a consortium of investors. In addition, the project requires extensive interaction between the investors, customers, all levels of government, contractors, labour unions, and the general public to obtain permits and approvals, establish royalty and tax structure, arrange for the needed infrastructure and negotiate site agreements and complex construction contracts. These factors must be considered at the initiation stage of a tarsands development program and they must be dealt with during the 40 year life of a lease development (Figure 3.3-1).

The development and execution phase of a tarsand mega-project is a massive undertaking requiring at least 10 years to complete, billions of dollars in capital investment and thousands of people before the first barrel of synthetic crude oil is produced. Even before this phase, the owner will have undertaken considerable site drilling and lease analysis in order to verify the preliminary feasibility of the venture.

The development period is comprised of many activities which the owner must address over a four to five year time frame; for example:

- set up organizations/consortium;
- ore body and site evaluations;
- plant/process selection;
- project feasibility;
- ERCB submissions and approval;
- marketing contracts;
- other negotiations and government fiscal decisions;
- decision to proceed; and
- planning for execution phase and managing contractor selection.

The execution period of five to six years is when the major capital outlays occur and hence is very critical to the success of the project.

The engineering and construction phase is a major undertaking taxing the capabilities and resources of the largest international contractors. Owners and managing contractors, in keeping with the objective of maximizing Canadian content on a project, find the need to ""farm-out" work to multiple offices, shops, contractors and a multitude of service organizations. Additionally, it is common for the managing contractor organization itself to be structured as a consortium, or some form of joint venture, in order to cope with the significant financial, resource and systems demands of the project.

Key activities typically undertaken during this phase include:

- plant/ process optimization;
- setting up engineer/procure/construct organizations and major contracts; and
- finalize project objectives (such as schedules, cost budgets and quality standards).

The managing contractor must structure his organization and adopt proven execution systems and procedures which can support the experienced personnel required to execute a tarsands mega-project. Both the owner and the managing contractor must recognize and plan for the many complexities which are characterized by:

- remote location;
- extensive preassembly, prefabrication, and staging facilities;
- pre start-up operating staff to assemble and train approximately 3,500 people;
- extended time frame (over two years) during which construction and commissioning/operations activities are being performed concurrently;
- construction by union labour under site labour agreements which are negotiated between the managing contractor and the Building Trades

Council. These agreements feature no strike - no lockout provisions. The magnitude of construction work is significant: 55 million manhours peaking at six thousand on-site personnel;

- engineering staffs are very large and decentralized in many locations. This adds to the cost and complexity of management. Engineering, procurement, construction and project management activities will require approximately six million contractor's home office manhours; and

- mega-projects can have a significant impact on the manufacturing, service and construction industries. In many cases they would tend to magnify their cyclic nature unless large tarsands projects could be sequenced to level out the significant demands on these industries.

3.3.6 Plant Operations

Assembling a team to operate and maintain a tarsands operation presents several significant problems:

- a "grass-roots" organization must be developed and methods, standards, and procedures implemented;

- the operations staff grows to about 3,500 people in a period of six to eight years;

- although operating experience is required, it is difficult to attract and retain experienced personnel in a remote location, such as northern Alberta;

- to supplement experienced personnel, significant training is normally required for less experienced employees;

- the turnover of personnel is typically much higher than at less remote locations;
- maintaining a tarsands plant in a remote location, and possibly during extreme weather, places unusual demands on maintenance staff; and
- the size of component equipment items and the lack of experienced supplemental maintenance labour for periodic maintenance shut-downs, plus the difficulty in assembling shut-down teams for unplanned shut-downs, place additional demands on the permanent plant staff.

The front-end of a tarsands plant is a materials handling operation while the upgrading portion is a continuous fluid process; a combination which is unique. The plants are also highly integrated from an energy/utilities point of view. All of these sections have developed in different industries with separate operating philosophies, different concepts of reliability and service factor, and design philosophies that are not necessarily common across the project.

The initial start-up of a plant and the "shake down" time to achieve stable operations at the design capacity requires a much longer time than that experienced in other processing operations, due to the size, location, facilities complexity, staff experience, weather, etc. The period from initial start-up to achieve stable operations at design capacity, based on experience at the two operating plants, is in the order of six years, during which time additional investment is required for fix-up and revamp, and revenues are reduced.

3.3.7 Market and Product Quality

The high production rate of synthetic crude oil from a mega-project is a significant percentage of Canadian consumption. A 15.9k m^3/CD (100,000 BPCD) plant would provide almost 10 percent of Alberta's conventional crude, and approximately 35 percent of Canada's present projection of 1982 import levels.

Current commercial terms recognize priority access to markets for synthetic crude oils, and this, plus the significant impact one plant has on the total market requires that synthetic crude be a good quality product, with direct substitutability for conventional crude, so as not to impose unusual strains upon the refiners processing this oil. While it might be possible for the market to absorb a smaller quantity, such as 2.4 - 3.2k m^3/CD (15,000 - 20,000 BPCD) of a lesser quality product, it would be difficult to market 15.9k m^3/CD (100,000 BPCD) of a lesser quality crude without providing both lead time and financial incentives for refiners to adjust to the additional burden placed on them (a lesser quality crude can be interpreted as one of lower gravity, higher sulphur content or inferior boiling range, etc.). Extensive changes to the characteristics and quality of the product are not easily achieved after the plant is built as the plant must be designed for a particular product over a long period of time, (25 - 30 years). Marketing strategies must cover a similar period.

3.3.8 Socio-Economic Impacts and Benefits

A tarsands mega-project has many economic benefits for Canada, both locally and nationally. The project economic life, including the development, execution and operations phases, will span some 35 to 40 years.

The project will create very significant employment opportunities. Engineering, procurement, construction and project management activities will require approximately three thousand contractor's home office man-years of work. Construction labour, and labour support, including field non-manual requirements, would peak at about six thousand plus and require in the order of 28 thousand man-years of work. Urban and residential development would entail about five thousand man-years of activity. Taking into account the employment impact in equipment and material manufacturing shops and other indirect and induced impacts, it is estimated that the employment created during the engineering, procurement and construction phase would be in the order of 150,000 man-years. The economic and employment impact on different parts of Canada are shown on Figure 3.3-3. This data has been developed from information published by Alsands Energy Ltd.

During the operations phase, the operating and maintenance organizations, including contract maintenance, would require about four thousand full time employees. A full-time job is created for every 25 barrels per day of synthetic crude production capacity. This, of course, excludes the indirect and induced employment created as a result of the operation. Taking into account the indirect and induced employment spin-off effects, a full-time job is created for every six barrels per day of synthetic crude production capacity.

Employment and training, in the form of skill upgrading, is afforded not only to the local people but also to many others during the construction and operations phases. During the construction period the emphasis is on training people for employment during the operations phase. By virtue of the training and the employment of peoples indigeneous to the area, the quality of life in local communities is improved. Additionally, local business opportunities during the construction and operations phases are created for local contractors and entrepreneurs.

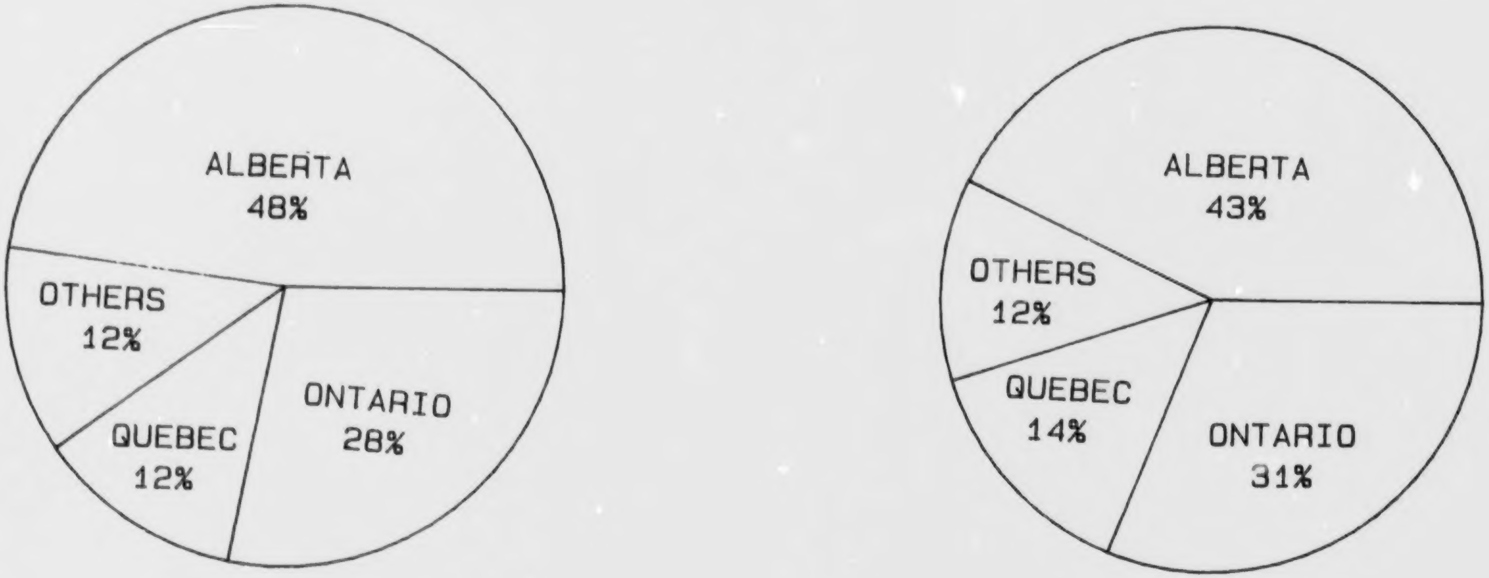
It is conservatively estimated that 85 percent of the resources, as measured by dollars required during the execution phase of the project, would be supplied from within Canada.

The project would require either the development of a new townsite or, alternatively, significant expansion of Fort McMurray, including that town's infrastructure.

A tarsands mega-project has some potential adverse socio-economic impacts on local communities and towns, which must be considered and

FIGURE 3.3-3

TARSANDS MEGA-PROJECT
IMPACT ON CANADIAN ECONOMY
CONSTRUCTION PHASE



ECONOMIC IMPACT

EMPLOYMENT IMPACT

addressed in the planning or development phase and carefully managed during the construction phase. Construction camp and recreational facilities must be designed, organized and operated in a manner that will minimize the desire of construction workers to visit local communities and the town of Fort McMurray. Hours of work and rotational leaves also require careful considerations. Despite good planning, either a new town or an expanded Fort McMurray will experience rapid growth as the project moves through the construction phase into the commissioning and operations phases. This rapid growth will potentially impact on the abilities of educational, health and social services to respond adequately.

A tarsands mega-project can, by virtue of its high labour force requirements, contribute adversely to the cyclic demands of the construction industry.

The synthetic crude oil production will contribute to improved security of supply and Canada's balance of payments. A 15.9 k m^3/CD (100,000 BPCD) of synthetic crude production represents about 35 percent of Canada's present import of crude oil. At an assumed crude price of $40 per barrel, this has a positive impact on balance of payments to the extent of about 1.5 billion dollars per year.

The payments of municipal taxes, income taxes, royalties and other federal taxes will provide revenues to the governments at all three levels for use in generating other undertakings.

4.0 ALTERNATE SCHEMES

4.1 Introduction

The Concept Development Team developed a list of feasible development scenarios which are judged to include all of the probable development cases over a size range from 4k m^3/CD (25,000 BPCD) to 15.9k m^3/CD (100,000 BPCD) of bitumen. The size range and specific sizes selected were arbitrarily chosen and took into account a minimum size that would be close to the low end of the range of interest and a maximum size selected as the mega-project base case.

The cases identified are displayed in matrix format in Table 4.1-1.

Four major structural categories were considered by the Concept Development Team. These are:

- integrated plant facilities with the upgrader adjacent to, and integrated with, the mining/extraction units from an energy viewpoint;
- "piggybacked" cases feeding extracted bitumen to a modified Suncor Inc. or Syncrude Canada Ltd. plant from a separate mine/extraction complex;
- distributed facilities with an energy-independent mine/extraction unit delivering dilute extracted bitumen to a remote upgrader via pipeline. The upgrader is anticipated to be in the Edmonton area; and
- "piggybacked" cases delivering dilute, extracted bitumen to a modified existing refinery via a pipeline. The refinery would probably be in the Edmonton area.

Table 4.1-1

Alternate Schemes for Tarsands Development

Scale	4k m^3/CD* (25,000 BPCD)			8k m^3/CD (50,000 BPCD)			15.9k m^3/CD (100,000 BPCD)			Staged Build-Up 4k m^3/CD to 15.9 k m^3/CD (25,000 BPCD to 100,000 BPCD)		
	Technology Alternatives			Technology Alternatives			Technology Alternatives			Technology Alternatives		
Configuration	Mine	Extraction	Upgrading	Mine	Extraction	Upgrading	Mine	Extraction	Upgrading	Mine	Extraction	Upgrading
Integrated plant facilities	1. Truck/ Shovel 2. Dragline/ Bucketwheel	1. Clark Hot Water	1. Fluid Coking 2. Delayed Coking	1. Truck/ Shovel 2. Dragline/ Bucketwheel	1. Clark Hot Water	1. Fluid Coking 2. Delayed Coking 3. H-Oil and Delayed Coking 4. H-Oil Gasification and POX	1. Truck/Shovel 2. Dragline/ Bucketwheel 3. Examine multiple mines	1. Clark Hot Water	1. Fluid Coking 2. Delayed Coking 3. H-Oil and Delayed Coking 4. H-Oil, Gasification and POX	1. Technology as appropriate 2. Examine multiple mines	1. Clark Hot Water	1. Technology as appropriate
Piggyback at Suncor Inc. or Syncrude Canada Ltd.	1. Truck/ Shovel 2. Dragline/ Bucketwheel	1. Clark Hot Water	1. H-Oil	1. Truck/ Shovel 2. Dragline/ Bucketwheel	1. Clark Hot Water	1. H-Oil	1. Truck/ Shovel 2. Dragline/ Bucketwheel 3. Multiple mines	1. Clark Hot Water	1. H-Oil	---	---	---
Remote upgrader in Edmonton area	---	---	---	1. Best of mine options	1. Clark Hot Water	1. H-Oil and Delayed Coking 2. Delayed Coking	1. Best of mine options	1. Clark Hot Water	1. H-Oil and Delayed Coking 2. Delayed Coking	1. Technology as appropriate 2. Examine multiple mines	1. Clark Hot Water 2. Clark Hot Water and Direct Coking	1. Technology as appropriate 2. Hydrotreating
Piggyback at existing refinery	1. Best of mine options	1. Clark Hot Water	1. H-Oil	1. Best of mine options	1. Clark Hot Water	1. H-Oil and Delayed Coking 2. Delayed Coking	---	---	---	---	---	---

Notes:

* Volume of bitumen feed to upgrader per calendar day

4.2 Selection of Cases for Analysis

From the matrix developed by the Concept Development Team, Techman Engineering Ltd. selected a limited number of cases for Stage I evaluation. The cases selected were chosen for their ability to separately examine the effects of size, technology, ownership and structure, relative to a mega-project base case, and to thus provide directional information for Stage II of the study. In examining the selected cases, it was believed that preliminary conclusions relative to size, technology and structure could be developed.

Piggyback cases each require a special business arrangement and capital and operating cost data that can only be developed with the participation and assistance of the owners and, therefore, have not been examined in any detail in Stage I.

In selecting cases for examination, only proven technology, or technology judged to be easily extrapolable was considered, since it was concluded that if the only successful projects depended on the development of technology, an event surrounded by uncertainty, there would be little enthusiasm to proceed on the part of potential owners. If, however, a potentially successful development case can be identified, using existing technology, then technological developments would presumably lead to even better cases which will be identified in Stage II.

Among the cases selected, there are several that are not necessarily technically practical as presently scoped, for example the small plants with single extraction trains, and small mining schemes based on bucketwheels and draglines. In evaluating these schemes, allowances were made in capital costs to account for additional components anticipated to be required by detailed design and optimization.

The nine cases selected for Stage I evaluation are summarized in Table 4.2-1 and are more completely described in Section 4.3 of this report and the accompanying appendix volume (Volume III).

Table 4.2-1

Summary of Selected Cases

Case	Capacity* (k m^3/CD) [BPCD]	Staging	Configuration	Mine			Extraction			Upgrading				Utilities	Remarks
				Scheme	Trains	Special Features	Scheme	Trains	Special Features	Scheme	Trains		Special Features	Special Features	
											Primary	Secondary			
1	15.9 [100,000]	1	I	BWE/DL	3		CHW	3		F.C.	2	2		Self generation of steam and power	
2	15.9 [100,000]	1	I	T/S	-		CHW	3		F.C.	2	2		Same as Case 1	
3	4.0 [25,000]	1	I	T/S	-		CHW	1		F.C.	1	1		Same as Case 1	
4	4.0 [25,000]	1	I	BWE/DL	1		CHW	1		F.C.	1	1		Same as Case 1	
5	4.0 [25,000] 15.9 [100,000]	2	I	T/S	-		CHW	1 3		F.C. H-Oil/F.C.	1-F.C. 2-H-Oil	1 2		Same as Case 1	
6	4.0 [25,000] 15.9 [100,000]	2	R	T/S	-		CHW	1 3		D.C. H-Oil/D.C.	1 1-D.C. 2-H-Oil	1 2	BPU at site	Purchase power; L.P. Steam at site	Diluent pipeline product coke
7	8.0 [50,000]	1	I	T/S	-		CHW	2		F.C.	1-F.C.	1		Same as Case 1	
8	8.0 [50,000]	1	R	T/S	-		CHW	2		H-Oil/D.C.	1-D.C. 2-H-Oil	2	BPU at site	Same as Case 6	Diluent pipeline product coke
9	15.9 [100,000]	1	R	T/S	-		CHW	3		H-Oil/D.C.	1-D.C. 3-H-Oil	3	BPU at site	Same as Case 6	Diluent pipeline product coke

Notes:

* Volume of bitumen feed to upgrader per calendar day

(i) Sulphur and coke - no cost, no value
(ii) Fuel purchase - natural gas; diesel for T/S

Legend:

CHW	- Clark Hot Water
BPU	- Bitumen Preparation Unit
F.C.	- Fluid Coking
D.C.	- Delayed Coking
H-Oil	- Low Conversion H-Oil Hydrocracking
BWE	- Bucketwheel Excavator
T/S	- Truck and Shovel
I	- Integrated
R	- Remote

4.3 Case Descriptions

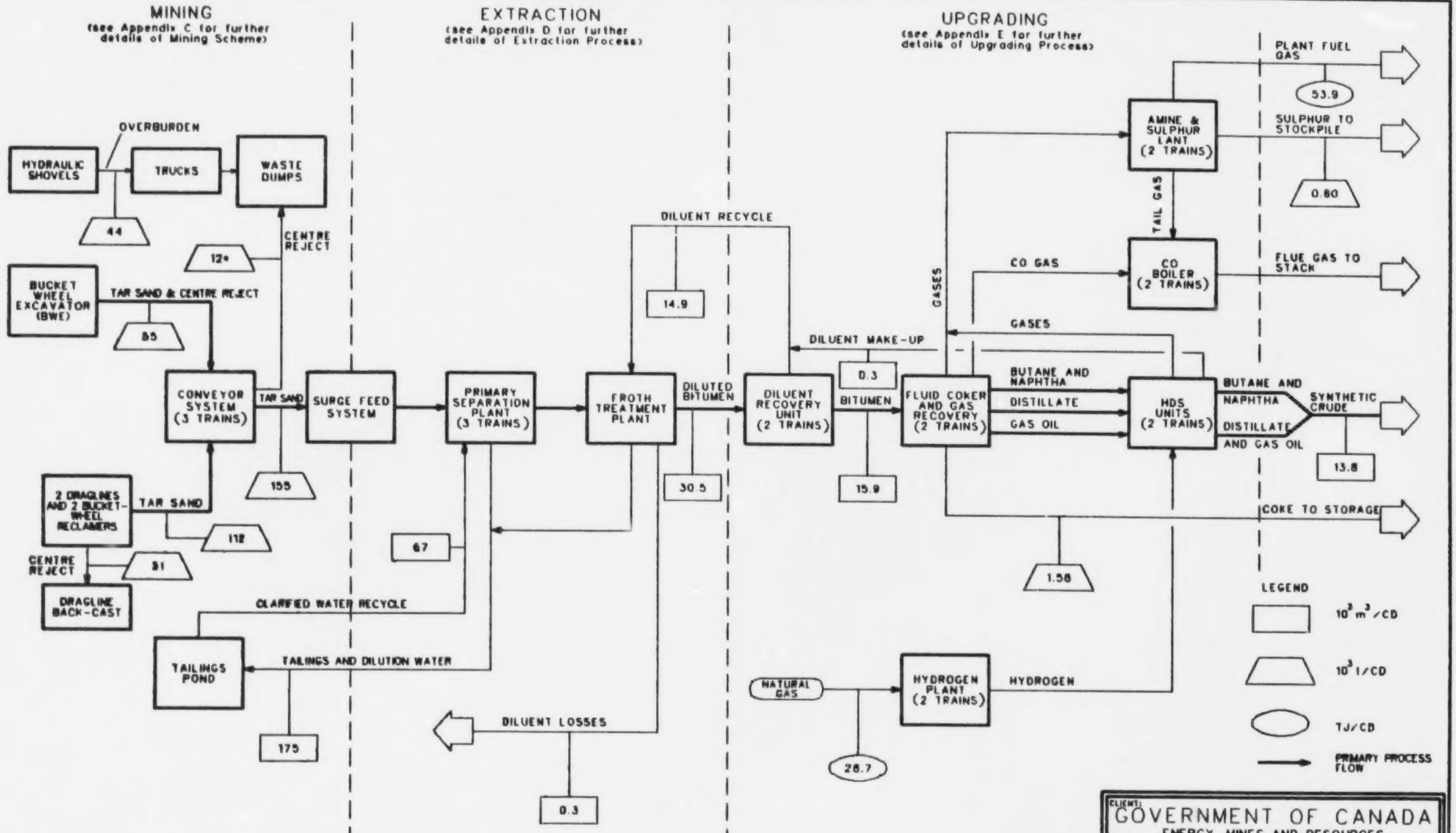
The following subsections summarize the mining, extraction, upgrading, utilities and general and off-plot components of the nine selected cases. It should be noted that the 15.9k m^3/CD (100,000 BPCD) mega-project discussed in Section 3.0 is sized in terms of synthetic crude production. The size of the schemes described in this section are in terms of the volume of bitumen feed to the upgrader. A more detailed description of these components can be found in the Appendices to this report (Volume III).

4.3.1 Case 1

Case 1, The Base Case, is a typical mega-project development producing 15.9k m^3/CD (100,000 BPCD) of extracted bitumen and processing it to synthetic crude. The mining scheme is based on draglines, bucketwheel excavators, bucketwheel reclaimers and conveyors, feeding tarsands to a three train Clark Hot Water Extraction Unit. The upgrading and utilities configuration is similar to those at Syncrude Canada Ltd. with two trains of Fluid Coking as the primary upgrading process, followed by hydrotreating. A process flow summary and an integrated utility flow summary for Case 1 are shown in Figures 4.3-1 and 4.3-2, respectively.

4.3.1.1 Mining

The mining scheme developed for Case 1 makes use of a bucketwheel excavator, draglines, bucketwheel reclaimers and conveyors, to mine tarsand in a multibench configuration and transport it to an extraction plant located at the edge of the mine. A rectangular ore body has been assumed. It has been sized at approximately 4 km x 4 km areal extent, given the production rate of 15.9k m^3/CD (100,000 BPCD) of bitumen and other factors specified in Appendix C. One bucketwheel excavator (BWE) digs plant feed material as well as lean tarsand and clay (centre reject) in the upper tarsand bench, while two draglines excavate and windrow the feed from the lower tarsand bench, back-casting centre


MINING
(see Appendix C for further details of Mining Scheme)
EXTRACTION
(see Appendix D for further details of Extraction Process)
UPGRADING
(see Appendix E for further details of Upgrading Process)
HYDRAULIC SHOVELS
OVERBURDEN
TRUCKS
WASTE DUMPS
44
CENTRE REJECT
12*
BUCKET WHEEL EXCAVATOR (BWE)
TAR SAND & CENTRE REJECT
85
CONVEYOR SYSTEM (3 TRAINS)
TAR SAND
155
SURGE FEED SYSTEM
2 DRAGLINES AND 2 BUCKET-WHEEL RECLAIMERS
TAR SAND
112
CENTRE REJECT
31
DRAGLINE BACK-CAST
PRIMARY SEPARATION PLANT (3 TRAINS)
67
CLARIFIED WATER RECYCLE
TAILINGS POND
TAILINGS AND DILUTION WATER
175
FROTH TREATMENT PLANT
DILUENT RECYCLE
14.9
DILUTED BITUMEN
30.5
DILUENT LOSSES
0.3
DILUENT RECOVERY UNIT (2 TRAINS)
DILUENT MAKE-UP
0.3
BITUMEN
15.9
FLUID COKER AND GAS RECOVERY (2 TRAINS)
GASES
CO GAS
GASES
BUTANE AND NAPHTHA
DISTILLATE
GAS OIL
1.58
COKE TO STORAGE
AMINE & SULPHUR LANT (2 TRAINS)
TAIL GAS
CO BOILER (2 TRAINS)
HDS UNITS (2 TRAINS)
PLANT FUEL GAS
53.9
SULPHUR TO STOCKPILE
0.80
FLUE GAS TO STACK
BUTANE AND NAPHTHA
DISTILLATE AND GAS OIL
SYNTHETIC CRUDE
13.8
NATURAL GAS
28.7
HYDROGEN PLANT (2 TRAINS)
HYDROGEN
LEGEND
$10^3 m^3/CD$
$10^3 t/CD$
TJ/CD
PRIMARY PROCESS FLOW

NOTES:

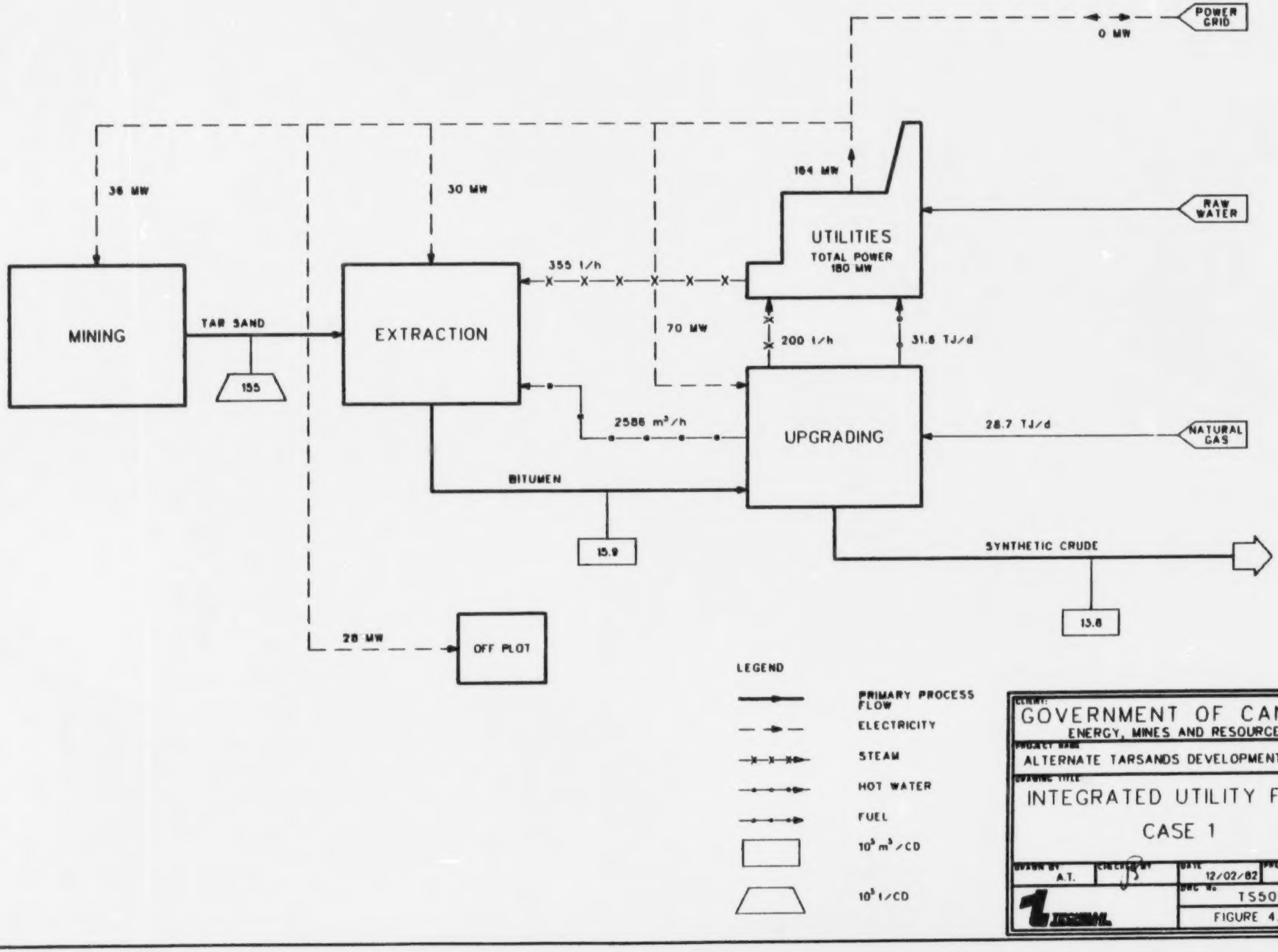
* WHEN BWE IN CENTRE REJECT, THIS RATE IS 85,000 t/d

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
PROCESS FLOW SUMMARY
CASE 1

DRAWN BY: A.T.	CHECKED BY:	DATE: 12/02/82	PROJECT No.:
		DWG. No.: TS500801	
		FIGURE 4.3-1	


POWER GRID
0 MW
36 MW
30 MW
164 MW
UTILITIES
TOTAL POWER 180 MW
RAW WATER
355 t/h
MINING
TAR SAND
155
EXTRACTION
70 MW
200 t/h
31.6 TJ/d
2586 m³/h
UPGRADING
28.7 TJ/d
NATURAL GAS
BITUMEN
15.9
SYNTHETIC CRUDE
13.8
28 MW
OFF PLOT
LEGEND
PRIMARY PROCESS FLOW
ELECTRICITY
STEAM
HOT WATER
FUEL
10³ m³/CD
10³ t/CD

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
INTEGRATED UTILITY FLOW
CASE 1

DRAWN BY	CHECKED BY	DATE	PROJECT No.
A.T.		12/02/82	

DWG No. TS500802

FIGURE 4.3-2

reject into the mined-out pit. Two bucketwheel reclaimers (BWR) load windrowed tarsand onto the belt conveyors which transport it to the Extraction Plant. Material transfer between the BWE (or BWR's) and the face conveyor is accomplished by belt wagons rather than conveyor bridge to provide operational flexibility.

Trucks and hydraulic shovels are used to strip the overburden materials ahead of tarsands mining. Front-end-loaders (FEL) and trucks are used to remove muskeg ahead of the overburden bench. This operation includes removal of the organic materials (muskeg) as well as the underlying layer of soft materials, such as clay. The activity is limited to the winter months. Overburden materials are permanently stored in an out-of-pit waste dump in the initial stage of the development, and in an in-pit backfill as soon as space permits. Centre reject is also placed into the in-pit waste dump.

The feed surge pile system located between the mine and the plant is designed to "smooth" the flow of tarsand from the BWE and BWR's to the conditioning drums in the Extraction Plant.

Tailings from the Extraction Plant are permanently stored in an out-of-pit tailings pond. Cycloning method of dyke construction, as proposed by Alsands Energy Ltd., has been assumed for the tailings pond dyke. This method is not commercially proven for tarsands tailing dykes and requires additional pilot work. Clarified water from the top of the tailings pond is recycled back into the Extraction Plant using a barge/ pump house and a pipeline.

4.3.1.2 Extraction

The extraction process design is based on the K.A. Clark Hot Water Process.

In the feed surge area, the mechanical layout would include three trains of mass flow hoppers, feeders and conveyors to supply the Primary Separation Plant.

The Primary Separation Plant will include three conditioning drums and separation vessels, with associated multiple banks of middlings treatment flotation equipment, tailings pumping equipment, deaerators and bitumen transfer pumps for froth pumping to the Froth Treatment Plant.

The Froth Treatment Plant will include two stages of dilution centrifuging with multiple centrifuges in each stage. Naphtha addition, filters, tailings pumps and other support equipment are included to meet the mechanical requirements of a conventional froth treatment process plant.

4.3.1.3 **Upgrading**

The upgrading scheme for Case 1 is virtually identical to Syncrude Canada's scheme at Fort McMurray. The entire upgrader is located adjacent to the mine site in the Fort McMurray region. In Case 1, 15.9k m^3/CD (100,000 BPCD) of bitumen is processed in two equal size parallel trains.

The Primary Upgrader is Fluid Coking which is a carbon rejection process licensed by Exxon Research and Engineering. The Secondary Upgrader is basically made up of three Hydrotreaters (or Hydro Desulphurization Units) and support units such as Hydrogen Plants, Amine Units and Sulphur Plants. The Hydrotreaters are necessary to ensure stable, low sulphur and low nitrogen synthetic oil.

Hydrogen is produced by steam-methane reforming of fuel gas. The feed gas is primarily imported natural gas, supplemented with some plant fuel gas. Total natural gas imports are 28.7 TJ/CD.

Net fluid coke production is assumed stockpiled and therefore has no value. Sulphur production is assumed sold at no net value.

Synthetic crude production for Case 1 is 13.8k m^3/CD (86,800 BPCD). It is pipelined to the Edmonton area via expanded Alberta Oil Sands Pipeline (AOSPL) facilities, on a tariff basis.

4.3.1.4 Utilities

The utility design concept is based on principles of providing self-sufficiency of energy within the complex, generating all required steam and electricity, with the exception of natural gas which is imported to supplement the plant fuel gas produced.

The entire complex, from an energy standpoint, is closely integrated, the Utility Plant acting as the major supplier of energy.

There are four major forms of energy used in the complex: electricity, steam, hot water and fuel in a gaseous form. Electricity is generated entirely in the Utility Plant and supplied to all the process areas. A back-up supply of electricity is provided through a tie to the Alberta Interconnected System (AIS).

Steam is generated in both the Upgrading and the Utility Plants. Most of the steam generated in upgrading is used internally, but under the normal operating conditions there is some excess high pressure steam available which is exported to the Utility Plant. The high pressure steam from upgrading, as well as what is generated in the Utility Plant, is used to generate electricity and provide the low pressure steam required at the Extraction Plant.

Energy required for heating hot water for the extraction process is supplied by low level heat available from the Upgrading Plant. Under some operating modes when heat from upgrading is not available in sufficient quantities, it is supplemented by low pressure steam from the Utility Plant.

Upgrading produces plant fuel gas which is used in the process areas as well as in the Utility Plant. Imported natural gas supplements the plant fuel when required.

The major components of the Utility Plant consist of gas turbine-generators, back pressure turbine-generators, condensing turbine-generators, boilers, feed water system, water treatment plant, compressed air system, electrical substation and auxillaries.

For the purpose of better energy efficiency, the Utility Plant uses a combined cycle design. The exhaust gas from the gas turbine-generators is used to supplement heat required to generate steam in the heat recovery boilers. The gas turbines and steam generators are designed to be fired with either plant fuel gas or natural gas.

In order to meet the varying combinations of steam and electricity needs, back-pressure turbine-generators and condensing/extraction steam turbine-generators are installed.

Since a substantial portion of the steam is required as live steam for the process, the Utility Plant includes a large water treatment plant for make-up purposes. The Utility Plant also includes a compressed air system which supplies instrument and plant air requirements to upgrading and off-plots.

The Utility Plant has total installed steam boiler capacity of 990 t/h and electric generating capacity of 259 MW.

4.3.1.5 General and Off-Plot Areas

The general and off-plot areas for the typical tarsand project consists of all sitework and facilities within (and including) the fenced area which is not part of the major processing areas of Extraction, Upgrading and Utilities generation.

The major constituents of the general and off-plot areas are described below:

Site Preparation

This includes all clearing, grubbing, water control, stripping, rough grading, finish grading and surfacing, including road works and any other civil works which are general purpose.

Tankage

Tankage for all feedstocks, intermediate surge and product storage, water, effluents, byproducts and other tankage of a general nature is included here along with the required tank pads, dykes, foundations and the like.

Interconnecting Facilities

These include all elevated and grade level pipeways carrying product and service lines between all areas of the project.

Relief and Blowdown

This includes facilities from the battery limits of the plants or source areas through and including the blowdown drums, flare stacks and flare pits.

Electrical Distribution

A system provides for the reticulation of electrical energy from the public utilities point of delivery, to the Utility Generation Facility substation and to the first substation in each of the consuming areas.

Water Supply

This includes all facilities to obtain water from either approved natural sources or municipal sources and to store, clarify and deliver to the consuming areas. Water treating and cooling facilities are part of the Utility Generation Area.

Fire Protection

This includes all fire water loops and pumps and general purposes fire protection and fire fighting facilities and apparatus. Area specific systems are included within the user facility.

Sewage

This includes facilities for sanitary, storm, oily water and other effluents, other than extraction tailings.

General Purpose Buildings

These include the administration buildings, general maintenance and warehouse buildings, garages, guard and security buildings and the like. Area or plant specific buildings are included with the user area.

Control Centres and Communications

These include all centralized supervisory and automatic or computerized plant control systems and their connections and interfaces with plant areas along with all required buildings. Communications systems include all source-powered, wired and wireless telephone systems as well as telex and teleprinting and modern computer facilities.

General purpose mobile and portable equipment shop tools and the like are included as required.

All support and general purpose facilities for the mining and tailings areas are described under that heading and excluded from this section.

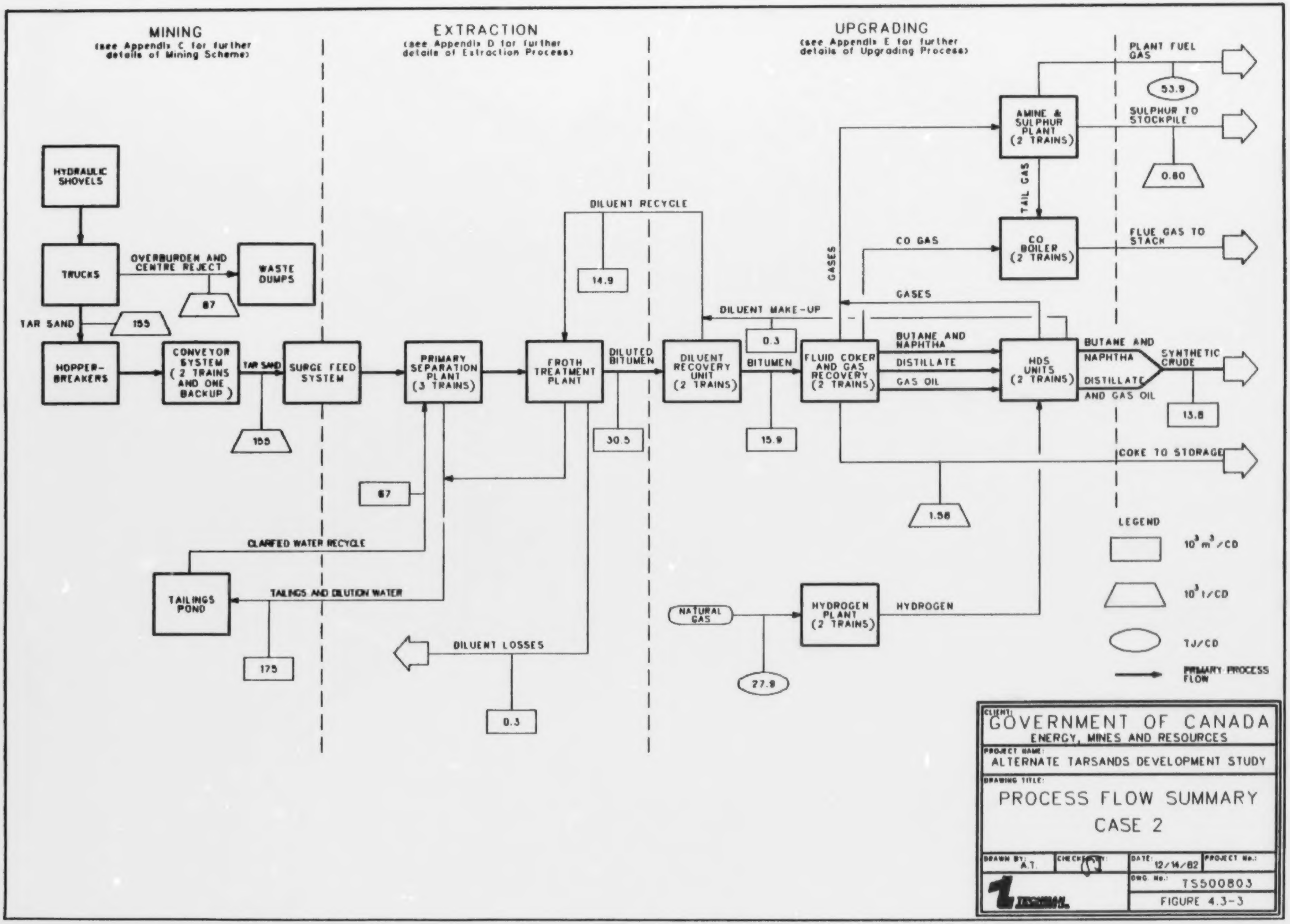
4.3.2 Case 2

Case 2 is identical to Case 1 except that the mining scheme is based on hydraulic excavators and mining trucks, and the Utility Plant is smaller because of the reduced electrical load of mobile mining equipment. A process flow summary and an integrated utility flow summary for Case 2 are shown in Figures 4.3-3 and 4.3-4, respectively.

The significant difference between this case and the base case, is the selection of mobile equipment for the mine rather than the historical bucketwheel/dragline approach.

4.3.2.1 Mining

The mining scheme for Case 2 utilizes hydraulic shovels (also known as hydraulic excavators) as a prime excavator for mining all materials with the exception of muskeg, for which FEL's are used. Large trucks (170 ton) transport tarsand from the shovels and dump it into a hopper/breaker located on the pit bottom. A relatively short conveyor transports tarsand from the hopper to the surge bins in the Extraction Plant. Overburden and centre reject are trucked to an in-pit waste dump. Only a small quantity of waste has to be stored out-of-pit during the initial phase of the operation.


MINING
(see Appendix C for further details of Mining Scheme)
EXTRACTION
(see Appendix D for further details of Extraction Process)
UPGRADING
(see Appendix E for further details of Upgrading Process)
HYDRAULIC SHOVELS
TRUCKS
OVERBURDEN AND CENTRE REJECT
87
WASTE DUMPS
TAR SAND
155
HOPPER-BREAKERS
CONVEYOR SYSTEM (2 TRAINS AND ONE BACKUP)
TAR SAND
155
SURGE FEED SYSTEM
PRIMARY SEPARATION PLANT (3 TRAINS)
87
CLARIFED WATER RECYCLE
TAILINGS POND
TAILINGS AND DILUTION WATER
175
FROTH TREATMENT PLANT
DILUENT RECYCLE
14.9
DILUTED BITUMEN
30.5
DILUENT LOSSES
0.3
DILUENT RECOVERY UNIT (2 TRAINS)
DILUENT MAKE-UP
0.3
BITUMEN
15.9
FLUID COKER AND GAS RECOVERY (2 TRAINS)
GASES
GASES
CO GAS
BUTANE AND NAPHTHA
DISTILLATE
GAS OIL
HDS UNITS (2 TRAINS)
BUTANE AND NAPHTHA
DISTILLATE AND GAS OIL
SYNTHETIC CRUDE
13.8
AMINE & SULPHUR PLANT (2 TRAINS)
TAIL GAS
CO BOILER (2 TRAINS)
PLANT FUEL GAS
53.9
SULPHUR TO STOCKPILE
0.80
FLUE GAS TO STACK
COKE TO STORAGE
1.58
NATURAL GAS
27.9
HYDROGEN PLANT (2 TRAINS)
HYDROGEN
LEGEND
$10^3 m^3/CD$
$10^3 t/CD$
TJ/CD
PRIMARY PROCESS FLOW

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

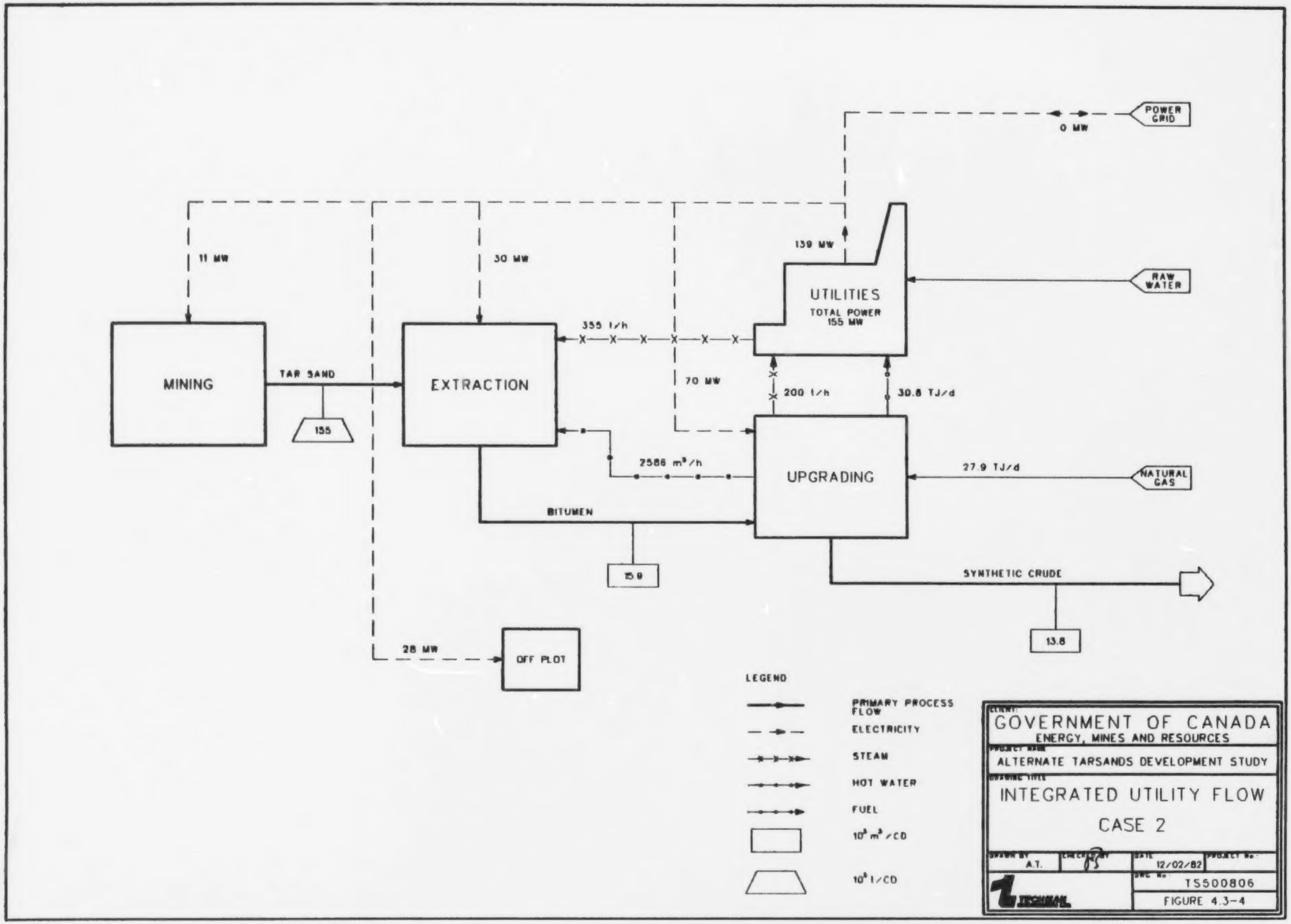
PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
PROCESS FLOW SUMMARY
CASE 2

DRAWN BY: A.T.
CHECKED BY:
DATE: 12/14/82
PROJECT No.:
DWG. No.: TS500803

TECHMAN

FIGURE 4.3-3


POWER GRID
0 MW
139 MW
11 MW
30 MW
UTILITIES
TOTAL POWER 155 MW
RAW WATER
355 l/h
MINING
TAR SAND
155
EXTRACTION
70 MW
200 l/h
30.8 TJ/d
2586 m³/h
UPGRADING
27.9 TJ/d
NATURAL GAS
BITUMEN
15.9
SYNTHETIC CRUDE
13.8
28 MW
OFF PLOT
LEGEND
PRIMARY PROCESS FLOW
ELECTRICITY
STEAM
HOT WATER
FUEL
10³ m³/CD
10³ l/CD

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE
INTEGRATED UTILITY FLOW
CASE 2

DRAWN BY	CHECKED BY	DATE	PROJECT No.:
A.T.		12/02/82	

DWG No. TS500806

FIGURE 4.3-4

A significant feature of this mining scheme is its modular approach which makes it applicable to a large number of ore bodies found in the surface mineable region of the Athabasca tarsands.

Eight hydraulic shovels will mine tarsands, overburden and centre reject, to provide the required production of 15.9k m^3/CD (100,000 BPCD) of bitumen. The number of trucks has been kept at a manageable level (31 required) by minimizing haul distances. The short haul has been achieved by applying the following principles:

- utilize geometry of radial (pie shaped) mining within the module;
- haul tarsand to a hopper/breaker located on the bottom near the apex of the pie shaped pit;
- use conveyor to transport tarsand out of the pit to the Extraction Plant;
- utilize an in-pit waste dump for overburden and centre reject disposal; and
- excavate narrow benches in radial direction, all the way to the pit bottom before proceeding, thus limiting the pit size; this results in lower preproduction overburden stripping and earlier in-pit waste disposal.

Two modules are developed concurrently, each being able to sustain the operation at the required production level provided some of the mobile equipment relocates temporarily from the second module. A third hopper/breaker/conveyor system is located adjacent to the Extraction Plant. It is used as a production system in the initial stages of mining when the pits are being opened. When the two modules are fully operational, the third system functions as a back-up.

In the analysis of the truck and shovel mining scheme, the factors not addressed quantitatively include the following:

- an increase in the bitumen saturation of the tarsand supplied to extraction, through application of mining selectivity possible with hydraulic shovels;
- increase in bitumen recovery in the extraction process due to the hydraulic shovel's ability to eliminate clay bands from the plant feed, again by application of its mode of digging which results in mining selectivity; and
- reduction in the tailings pond size through a lower volume of sludge caused by less fines in the plant feed (see item above).

The truck and shovel mining scheme is based on the utilization of good roads, therefore, availability of road building material is of the utmost importance. For the purpose of this study it was assumed that granular resources are located close to the mine, or that limestone will be at or close to the pit bottom. After the initial construction of a road network, a fleet of mobile equipment is assigned to maintain and relocate the roads as mining progresses. The fleet also provides road building material make-up, to offset rehandling losses.

The tailings disposal system and the recycle water system of Case 2 is the same as described in Case 1 (Section 4.3.1.1).

4.3.2.2 Extraction

The extraction process design is based on the K.A. Clark Hot Water Process.

The surge feed area has capital allowances in both the mine and extraction areas to allow effective materials handling of the tarsand feed requirements for the Primary Separation Plant.

The Primary Separation and Froth Treatment Plants are the same as described in Case 1 (Section 4.3.1.2).

4.3.2.3 Upgrading

The upgrading portion of Case 2 is identical to Case 1's upgrader (Section 4.3.1.3). The difference with Case 1 is the slightly lower natural gas imports at 27.9 TJ/CD.

4.3.2.4 Utilities

The configuration of the utility systems and the Utility Plant for Case 2 is identical to that for Case 1 (Section 4.3.1.4).

The only change from Case 1 is in the electric generating capacity of the Utility Plant which is smaller, due to less demands from the mining area.

The Utility Plant for this case has a total installed capacity of 990 t/h of steam and 224 MW of electricity.

4.3.2.5 General and Off-Plot Areas

The general and off-plot area requirements for Case 2 are as described for Case 1 (Section 4.3.1.5).

4.3.3 Case 3

Case 3 is based on the production of 4k m^3/CD (25,000 BPCD) of extracted bitumen using a mobile equipment mining scheme, a single Clark Hot Water extraction train with critical equipment spared to increase the service factor, and a single train of fluid coking and hydrotreating. The Utility Plant is similar to Case 2 but is scaled down to approximately one-fourth of the size. A process flow summary and an integrated utility flow summary for Case 3 are shown in Figures 4.3-5 and 4.3-6, respectively.

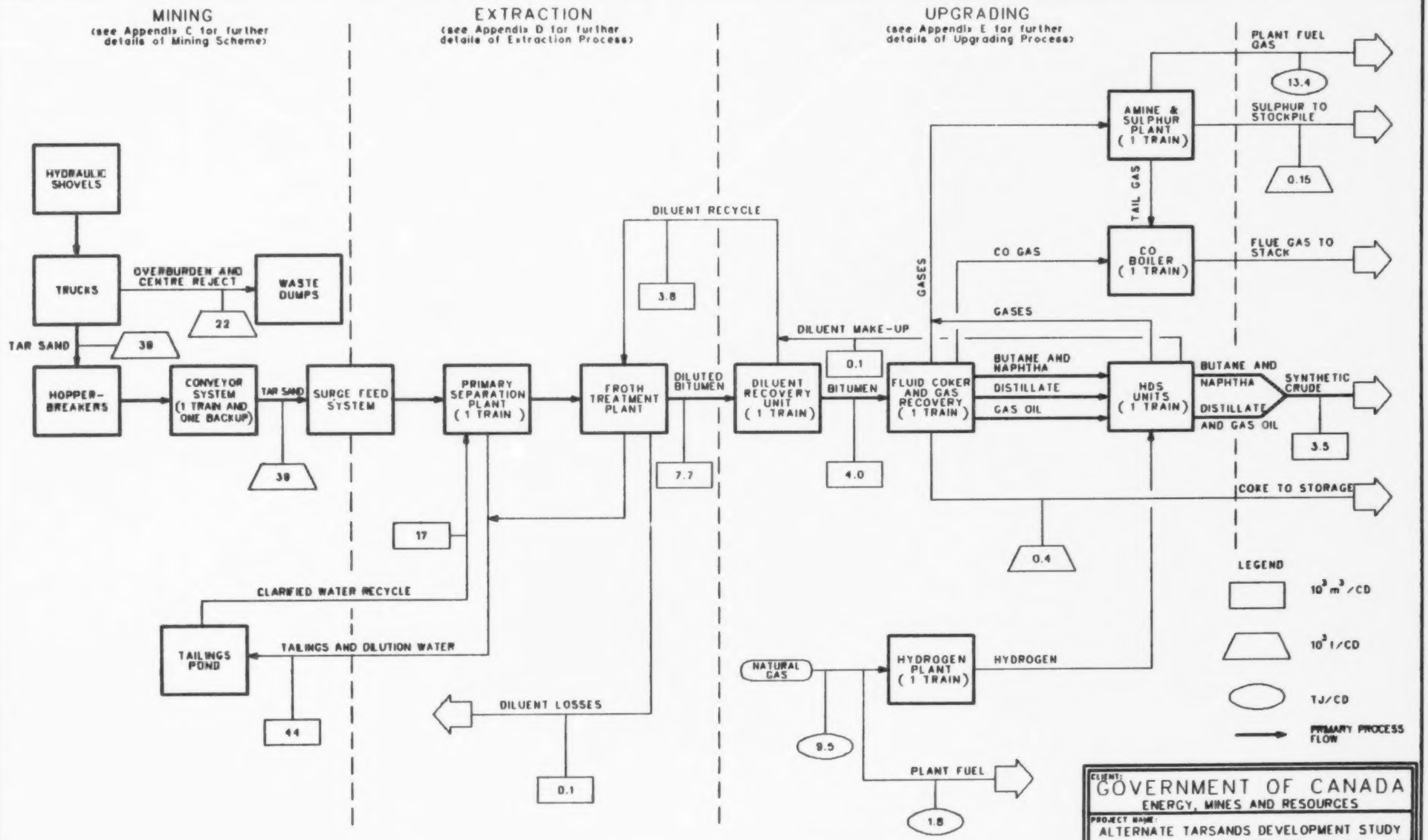
The significant difference between this case and the base case is the size, the choice of a single train through extraction and upgrading, and the selection of mobile mining equipment.

4.3.3.1 Mining

The mining scheme developed for Case 3 is a one module version of the Case 2 multi-module truck and shovel (hydraulic excavator) mining scheme. As in the 15.9k m^3/CD (100,000 BPCD) of bitumen case, the mining is commenced closest to the Extraction Plant with a temporary hopper/breaker - conveyor system. As the pit is being developed, a permanent hopper/breaker is installed on the pit bottom and tarsand is conveyed to the Extraction Plant from there. As soon as the permanent system is operational, the initial system assumes the role of a back-up system.

Three hydraulic shovels (Demag H241 or equivalent) will excavate overburden, tarsand and centre reject. The material will be transported by a fleet of 170 ton trucks (10 required). The same principles of short truck haul described in Case 2 also apply in Case 3. An additional advantage of a small mine is short conveying distance. As the centroid of the orebody is located closer to the Extraction Plant, the conveyor length required between the hopper/breaker and the Extraction Plant is reduced. The 4k m^3/CD (25,000 BPCD) of bitumen mine can be operated with a short conveyor and a permanent hopper/ breaker in one location for 25 to 30 years.

As with Case 2, availability of road building materials is a prerequisite, so that the extremely high rolling resistance of trucks moving on tarsand or waste dump can be eliminated.


MINING
(see Appendix C for further details of Mining Scheme)
EXTRACTION
(see Appendix D for further details of Extraction Process)
UPGRADING
(see Appendix E for further details of Upgrading Process)
HYDRAULIC SHOVELS
TRUCKS
OVERBURDEN AND CENTRE REJECT
22
WASTE DUMPS
TAR SAND
38
HOPPER-BREAKERS
CONVEYOR SYSTEM (1 TRAIN AND ONE BACKUP)
TAR SAND
38
SURGE FEED SYSTEM
PRIMARY SEPARATION PLANT (1 TRAIN)
17
FROTH TREATMENT PLANT
DILUTED BITUMEN
7.7
DILUENT RECYCLE
3.8
DILUENT RECOVERY UNIT (1 TRAIN)
DILUENT MAKE-UP
0.1
BITUMEN
4.0
FLUID COKER AND GAS RECOVERY (1 TRAIN)
GASES
CO GAS
GASES
BUTANE AND NAPHTHA
DISTILLATE
GAS OIL
HDS UNITS (1 TRAIN)
BUTANE AND NAPHTHA
DISTILLATE AND GAS OIL
SYNTHETIC CRUDE
3.5
COKE TO STORAGE
0.4
AMINE & SULPHUR PLANT (1 TRAIN)
TAIL GAS
CO BOILER (1 TRAIN)
PLANT FUEL GAS
13.4
SULPHUR TO STOCKPILE
0.15
FLUE GAS TO STACK
CLARIFIED WATER RECYCLE
TAILINGS POND
TAILINGS AND DILUTION WATER
44
DILUENT LOSSES
0.1
NATURAL GAS
9.5
HYDROGEN PLANT (1 TRAIN)
HYDROGEN
PLANT FUEL
1.8
LEGEND
10³ m³/CD
10³ t/CD
TJ/CD
PRIMARY PROCESS FLOW

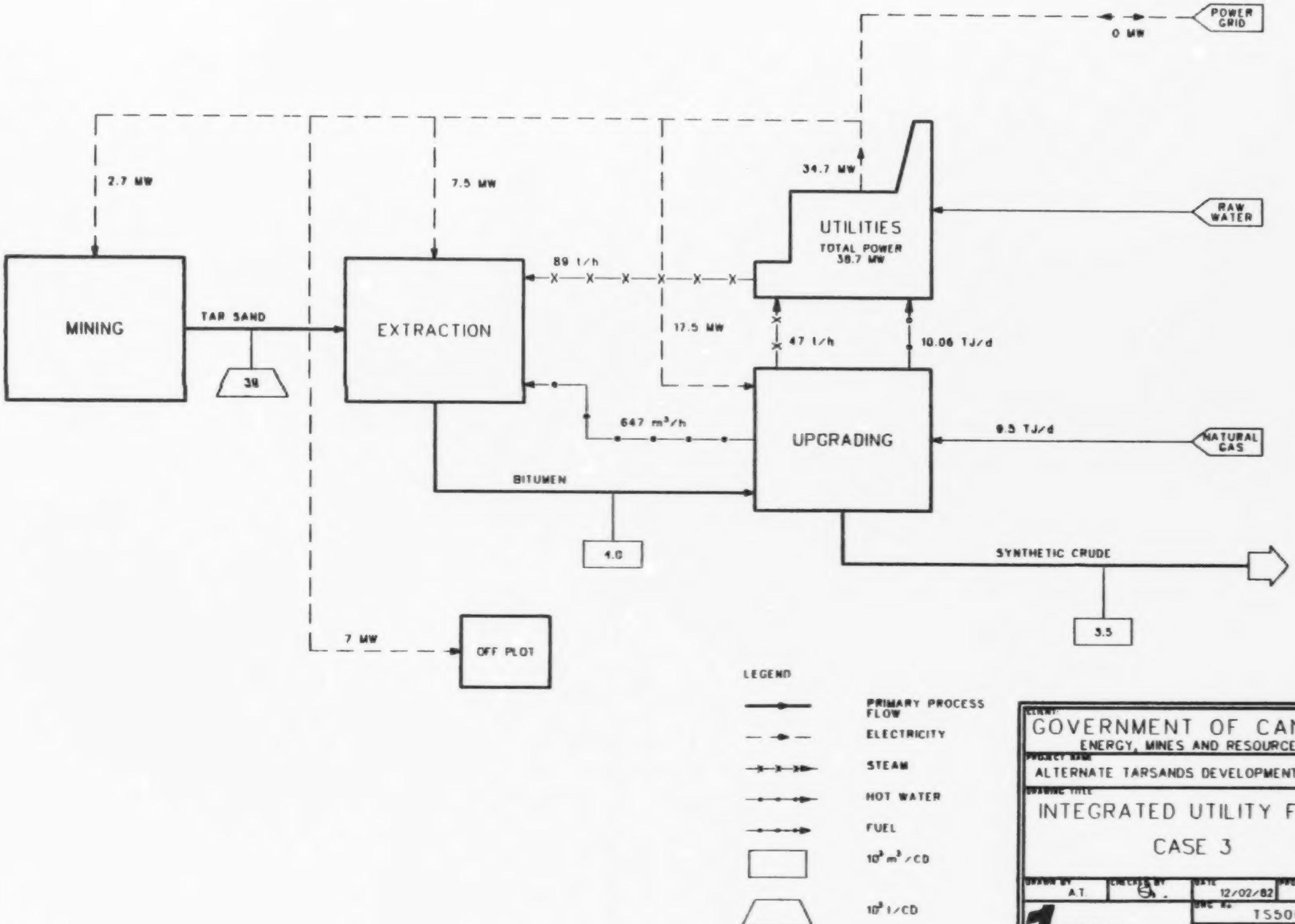
CLIENT: GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME: ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:

PROCESS FLOW SUMMARY
CASE 3

DRAWN BY: T.F.W.	CHECKED BY:	DATE 12/14/82	PROJECT No.:
		DWG. No.: TS500804	
		FIGURE 4.3-5	


POWER GRID
0 MW
2.7 MW
7.5 MW
34.7 MW
UTILITIES
TOTAL POWER 38.7 MW
RAW WATER
MINING
TAR SAND
38
EXTRACTION
89 t/h
17.5 MW
47 t/h
10.06 TJ/d
647 m³/h
UPGRADING
9.5 TJ/d
NATURAL GAS
BITUMEN
4.0
SYNTHETIC CRUDE
3.5
7 MW
OFF PLOT
LEGEND
PRIMARY PROCESS FLOW
ELECTRICITY
STEAM
HOT WATER
FUEL
10³ m³/CD
10³ t/CD

CLIENT
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
INTEGRATED UTILITY FLOW
CASE 3

DRAWN BY	CHECKED BY	DATE	PROJECT NO.
A.T.		12/02/82	

DWG NO. TS500807

FIGURE 4 3-6

An out-of-pit tailings pond is required, as is the case with all other mining schemes analyzed in the study. A small pit does not lend itself very well to in-pit dyke construction and tailings disposal during the life of the mining operation. However, if the pit is surrounded by uneconomical ore or no-ore configuration, the final pit could serve as a tailings pond for an adjacent operation without the necessity to build any in-pit dykes.

4.3.3.2 Extraction

The extraction process design is based on the K.A. Clark Hot Water Process.

In this case, the extraction facilities would be designed to process one quarter of the tarsand feed needed in Cases 1 and 2.

The feed surge area has capital allowances in both the mine and extraction areas to allow an effective interface to be designed to handle the tarsand feed requirements for the Primary Separation Plant.

The Primary Separation Plant will include one conditioning drum and a separation vessel, multiple banks of middlings treatment flotation equipment, tailings pumping equipment, and deaerator and bitumen transfer pumps for froth pumping to the Froth Treatment Plant.

The Froth Treatment Plant will handle one quarter of the flow rates of Cases 1 and 2 and will include two stages of dilution centrifuging with multiple centrifuges in each stage. Naphtha addition, filters, tailings pumps and other support equipment are included to meet the mechanical requirements of a conventional Froth Treatment Plant.

4.3.3.3 Upgrading

The Upgrader in Case 3 is a smaller, simplified version of Case 1. Only one train is provided to process 4k m^3/CD (25,000 BPCD) of bitumen.

The entire Upgrader is located adjacent to the mine site in the Fort McMurray region. The Primary Upgrader is Fluid Coking while the Secondary Upgrader is headed by two Hydrotreaters - naphtha and distillate/gas oil. All the imported natural gas that is needed to close the fuel balance is fed to the Hydrogen Plant.

The synthetic crude oil production for this case is 3.5k m^3/CD (22,000 BPCD). The AOSPL facilities are assumed expanded to pipeline this product to the Edmonton area on a tariff basis.

Net fluid coke production is assumed stockpiled and sulphur production is assumed sold at no net value.

4.3.3.4 Utilities

The configuration of the utility system and Utility Plant for Case 3 is essentially identical to those of Case 1 (Section 4.3.1.4).

The only changes are in the capacity of the Utility Plant to reflect the smaller size of the complex and the elimination of the condensing/ extraction turbine-generators.

Installed capacity of the plant is 150 t/h of steam and 71 MW of electricity.

4.3.3.5 General and Off-Plot Areas

The general and off-plot area requirements for Case 3 are as described for Case 1 (Section 4.3.1.5).

4.3.4 Case 4

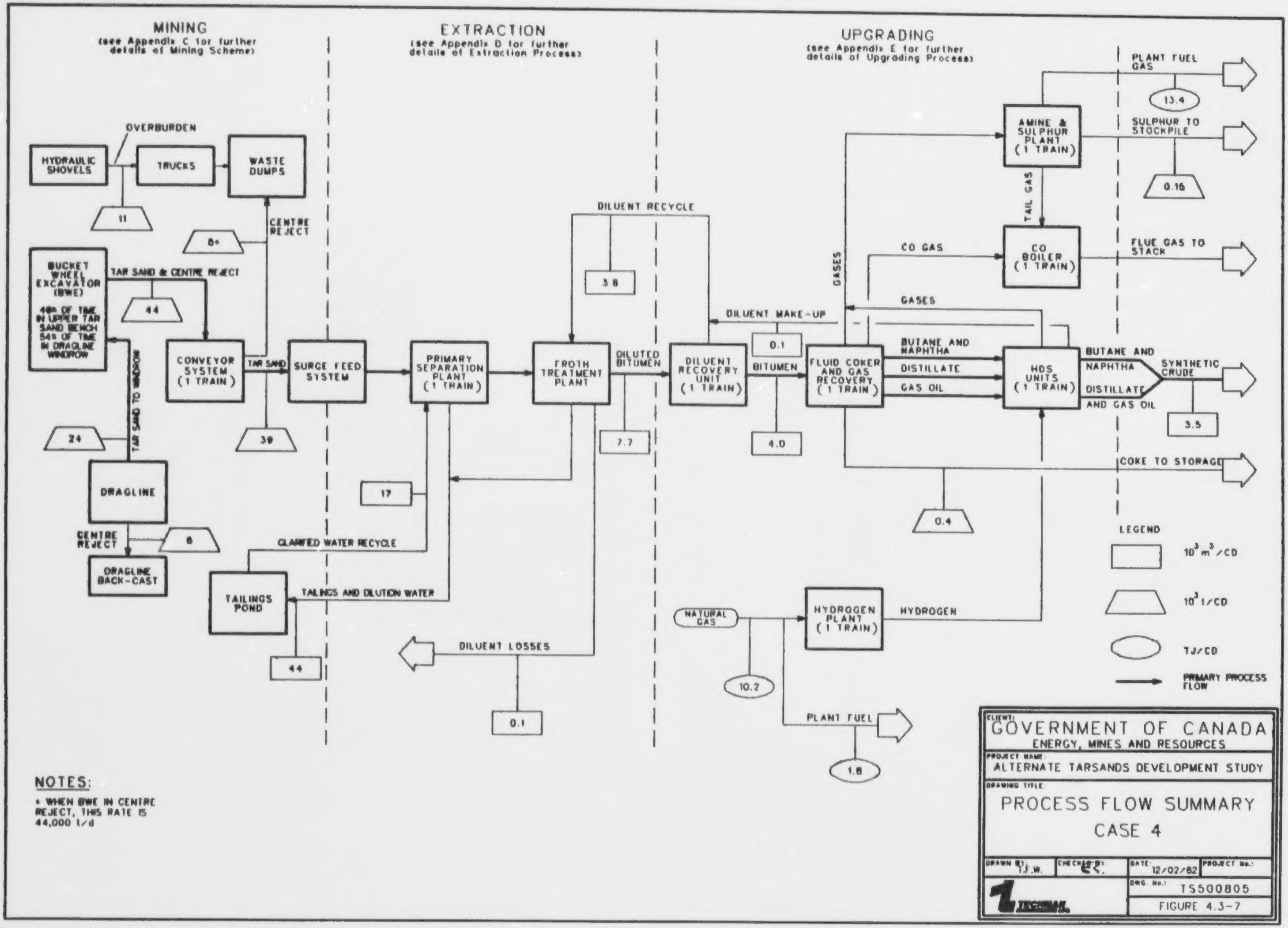
Case 4 is identical to Case 3, except that the mining scheme is based on bucketwheels and draglines and the electrical requirements are therefore higher than in a mobile equipment mine. A process flow summary and an integrated utility flow summary for Case 4 are shown in Figures 4.3-7 and 4.3-8, respectively.

The significant difference between this case and the base case is the size and the choice of a single train through extraction and upgrading.

4.3.4.1 Mining

Similar to Case 1, the mining scheme developed for Case 4 uses a BWE and a dragline in a multibench configuration. The BWE digs plant feed material and reject in the upper tarsand bench, while the dragline operates in the lower tarsand bench. Upon the completion of a pass in the upper tarsand bench, the BWE moves onto the dragline side of the face conveyor to load tarsand from the windrow onto the belt. The timing and coordination of the two prime excavators is of importance, and is discussed in Appendix C, Mining Schemes. The same muskeg and overburden stripping system as used in Case 1 is used for this case, with FEL and trucks for muskeg removal and hydraulic shovels and trucks for overburden removal.

The most significant feature of this mining scheme is a one train concept. To avoid system duplication in the mine which would result in very low capacity BWE's and draglines, and an increase in already high (compared to Case 3) initial capital costs, a relatively large plant feed surge system has been located between the Mine and the Extraction Plant. The surge system is similar to that employed at Syncrude Canada Ltd. An allowance in mobile equipment fleet has been made to operate it should the tarsand supply from the mine be interrupted. The most likely source of such interruptions would be the BWE. Long term inoperability


MINING
(see Appendix C for further details of Mining Scheme)
EXTRACTION
(see Appendix D for further details of Extraction Process)
UPGRADING
(see Appendix E for further details of Upgrading Process)
HYDRAULIC SHOVELS
OVERBURDEN
TRUCKS
WASTE DUMPS
11
CENTRE REJECT
0*
BUCKET WHEEL EXCAVATOR (BWE)
46% OF TIME IN UPPER TAR SAND BENCH 54% OF TIME IN DRAGLINE WINDROW
TAR SAND & CENTRE REJECT
44
CONVEYOR SYSTEM (1 TRAIN)
TAR SAND
39
TAR SAND TO WINDROW
24
DRAGLINE
CENTRE REJECT
6
DRAGLINE BACK-CAST
SURGE FEED SYSTEM
PRIMARY SEPARATION PLANT (1 TRAIN)
17
CLARIFIED WATER RECYCLE
TAILINGS POND
TAILINGS AND DILUTION WATER
44
FROTH TREATMENT PLANT
DILUENT RECYCLE
3.8
DILUTED BITUMEN
7.7
DILUENT LOSSES
0.1
DILUENT RECOVERY UNIT (1 TRAIN)
DILUENT MAKE-UP
0.1
BITUMEN
4.0
FLUID COKER AND GAS RECOVERY (1 TRAIN)
GASES
CO GAS
GASES
BUTANE AND NAPHTHA
DISTILLATE
GAS OIL
0.4
AMINE & SULPHUR PLANT (1 TRAIN)
TAIL GAS
CO BOILER (1 TRAIN)
HDS UNITS (1 TRAIN)
PLANT FUEL GAS
13.4
SULPHUR TO STOCKPILE
0.16
FLUE GAS TO STACK
BUTANE AND NAPHTHA
DISTILLATE AND GAS OIL
SYNTHETIC CRUDE
3.5
COKE TO STORAGE
NATURAL GAS
10.2
HYDROGEN PLANT (1 TRAIN)
HYDROGEN
PLANT FUEL
1.8
LEGEND
$10^3 m^3/CD$
$10^3 t/CD$
TJ/CD
PRIMARY PROCESS FLOW

NOTES:

* WHEN BWE IN CENTRE REJECT, THIS RATE IS 44,000 t/d

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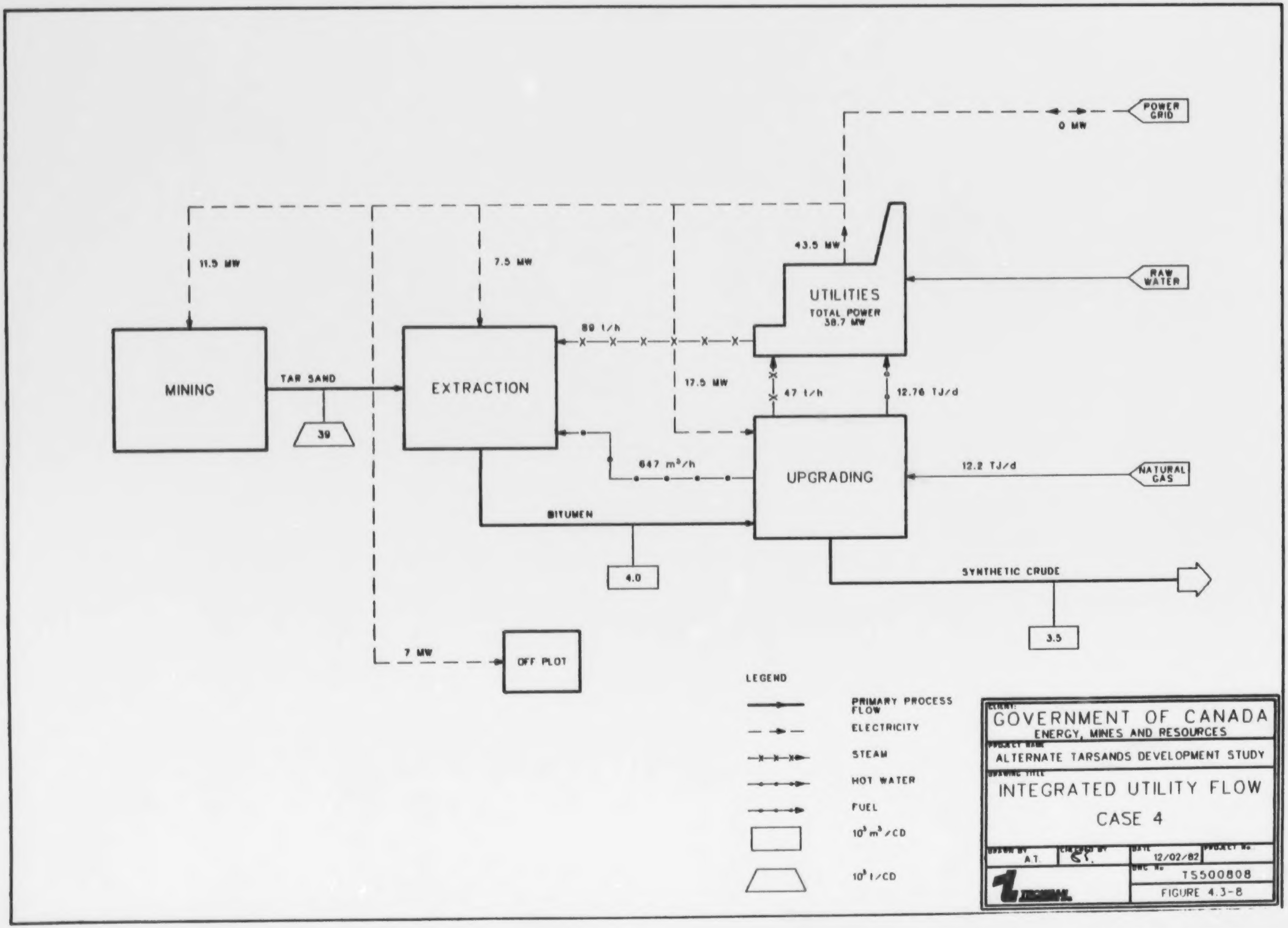
PROJECT NAME: ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE: PROCESS FLOW SUMMARY
CASE 4

DRAWN BY: T.J.W.	CHECKED BY: E.C.	DATE: 12/02/82	PROJECT No.:
TECHMAN		DWG. No.: TS500805	
		FIGURE 4.3-7	


POWER GRID
0 MW
11.5 MW
7.5 MW
43.5 MW
RAW WATER
UTILITIES
TOTAL POWER 38.7 MW
89 t/h
MINING
TAR SAND
39
EXTRACTION
17.5 MW
47 t/h
12.76 TJ/d
647 m³/h
UPGRADING
12.2 TJ/d
NATURAL GAS
BITUMEN
4.0
SYNTHETIC CRUDE
3.5
7 MW
OFF PLOT
LEGEND
PRIMARY PROCESS FLOW
ELECTRICITY
STEAM
HOT WATER
FUEL
10³ m³/CD
10³ t/CD

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE
INTEGRATED UTILITY FLOW
CASE 4

DESIGN BY	CHECKED BY	DATE	PROJECT No.
A.T.	G.T.	12/02/82	
		DWG No. TS500808	
		FIGURE 4.3-8	

of the BWE (major repair) would result in a complete shutdown - extraction first and upgrading later.

The tailings disposal system as well as the recycle water system have been assumed to be the same as in Case 3 (Section 4.3.3.1).

4.3.4.2 Extraction

The extraction process and mechanical equipment requirements are the same as those required in Case 3 (Section 4.3.3.2).

4.3.4.3 Upgrading

The upgrading portion of Case 4 is identical in configuration and yield to Case 3. The only difference between the two cases is in the quantity of natural gas import. In this particular case, the Hydrogen Plant demand is less than the import gas quantity; import gas is, therefore, diverted to supplement the plant fuel gas.

4.3.4.4 Utilities

Case 4 is identical with Case 3 except that the mining electrical load is greater due to the dragline and bucketwheel scheme.

Installed capacity is 150 t/h of steam and 82 MW of electricity.

4.3.4.5 General and Off-Plot Areas

The general and off-plot area requirements for Case 4 are as described for Case 1 (Section 4.3.1.5).

4.3.5 Case 5

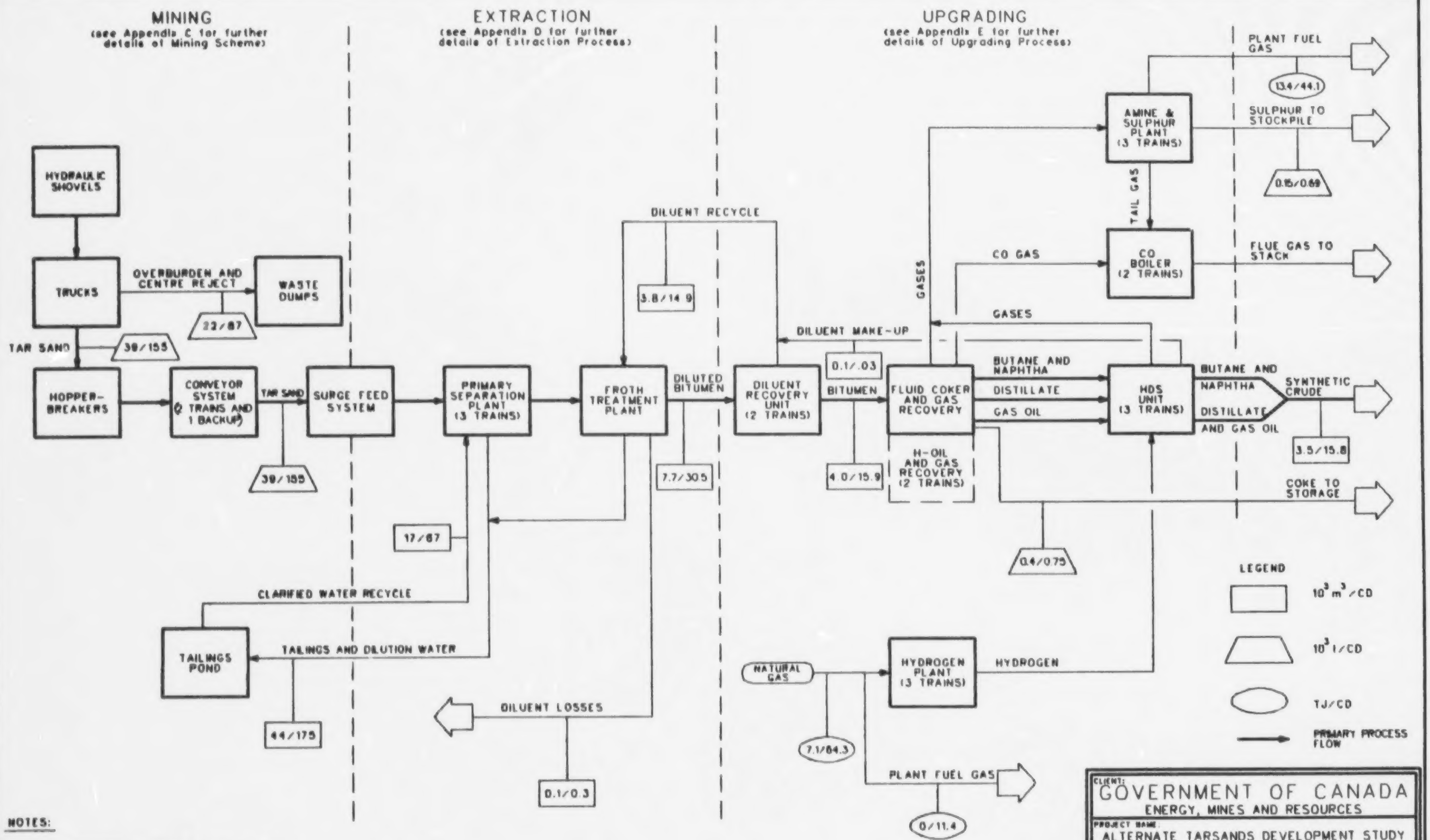
Case 5 is a build-up, or expansion case, in which it is anticipated that the plant's initial configuration would be similar to Case 3. The plant would then expand and the extraction, mining and utilities area would become similar to Case 2. The upgrading expansion would be accomplished by adding an H-Oil process in series with the initial Fluid Coker. A process flow summary and an integrated utility flow summary for Case 5 are shown in Figures 4.3-9 and 4.3-10, respectively. H-Oil, in this context, is a generic term for ebullated-bed hydrocracking. It is a proprietary process licensed by Hydro-Carbon Research Inc.

The significant difference between the case and the base case is that the ultimated capactiy is achieved in two steps, the primary upgrading technology in the final configuration is based on hydrogen addition rather than careon rejection, and the selected mining technology is mobile equipment.

4.3.5.1 **Mining**

A comparative, albeit preliminary, analysis of capital and operating costs indicated a trend towards the truck and shovel operation over the bucketwheel and dragline, even at the 15.9k m^3/CD (100,000 BPCD) of bitumen production level. Based on this analysis, it has been decided, that the build-up cases - Case 5 and Case 6, would employ trucks and shovels during the start-up years as well as during the full production years, i.e., at 15.9k m^3/CD (100,000 BPCD) of bitumen. The optional mining scheme - starting with trucks and shovels, and then adding bucketwheels and draglines later on has not been developed at this stage because of the above mentioned trends in capital and operating costs. It is suspected that one of the reasons for this apparent change in economics is due to recent developments and advancements in mobile mining technology. This represents a departure from the historic approach and will require much further development and substantiation in Stage II.

The mining scheme developed for Case 5 is based on the Case 2 mine layout and equipment. Due to lower initial throughput requirements, only one module would be opened during the first five years of production.


MINING
(see Appendix C for further details of Mining Scheme)
EXTRACTION
(see Appendix D for further details of Extraction Process)
UPGRADING
(see Appendix E for further details of Upgrading Process)
HYDRAULIC SHOVELS
TRUCKS
OVERBURDEN AND CENTRE REJECT
WASTE DUMPS
22/87
TAR SAND
39/155
HOPPER-BREAKERS
CONVEYOR SYSTEM (2 TRAINS AND 1 BACKUP)
TAR SAND
39/155
SURGE FEED SYSTEM
PRIMARY SEPARATION PLANT (3 TRAINS)
17/67
CLARIFIED WATER RECYCLE
TAILINGS POND
TAILINGS AND DILUTION WATER
44/175
FROTH TREATMENT PLANT
DILUENT RECYCLE
3.8/14.9
DILUTED BITUMEN
7.7/30.5
DILUENT LOSSES
0.1/0.3
DILUENT RECOVERY UNIT (2 TRAINS)
DILUENT MAKE-UP
0.1/.03
BITUMEN
4.0/15.9
FLUID COKER AND GAS RECOVERY
H-OIL AND GAS RECOVERY (2 TRAINS)
GASES
CO GAS
GASES
BUTANE AND NAPHTHA
DISTILLATE
GAS OIL
0.4/0.75
AMINE & SULPHUR PLANT (3 TRAINS)
TAIL GAS
CO BOILER (2 TRAINS)
HDS UNIT (3 TRAINS)
PLANT FUEL GAS
13.4/44.1
SULPHUR TO STOCKPILE
0.15/0.69
FLUE GAS TO STACK
BUTANE AND NAPHTHA
DISTILLATE AND GAS OIL
SYNTHETIC CRUDE
3.5/15.8
COKE TO STORAGE
NATURAL GAS
7.1/64.3
HYDROGEN PLANT (3 TRAINS)
HYDROGEN
PLANT FUEL GAS
0/11.4
LEGEND
10³ m³/CD
10³ t/CD
TJ/CD
PRIMARY PROCESS FLOW

NOTES:

1. 3.5/15.3 NUMBERS INDICATE INITIAL AND FINAL STAGE FLOWS
2. H-OIL AND GAS RECOVERY INDICATES UNIT INSTALLED IN FINAL STAGE
3. NUMBER OF TRAINS INDICATED REFERS TO FINAL STAGE

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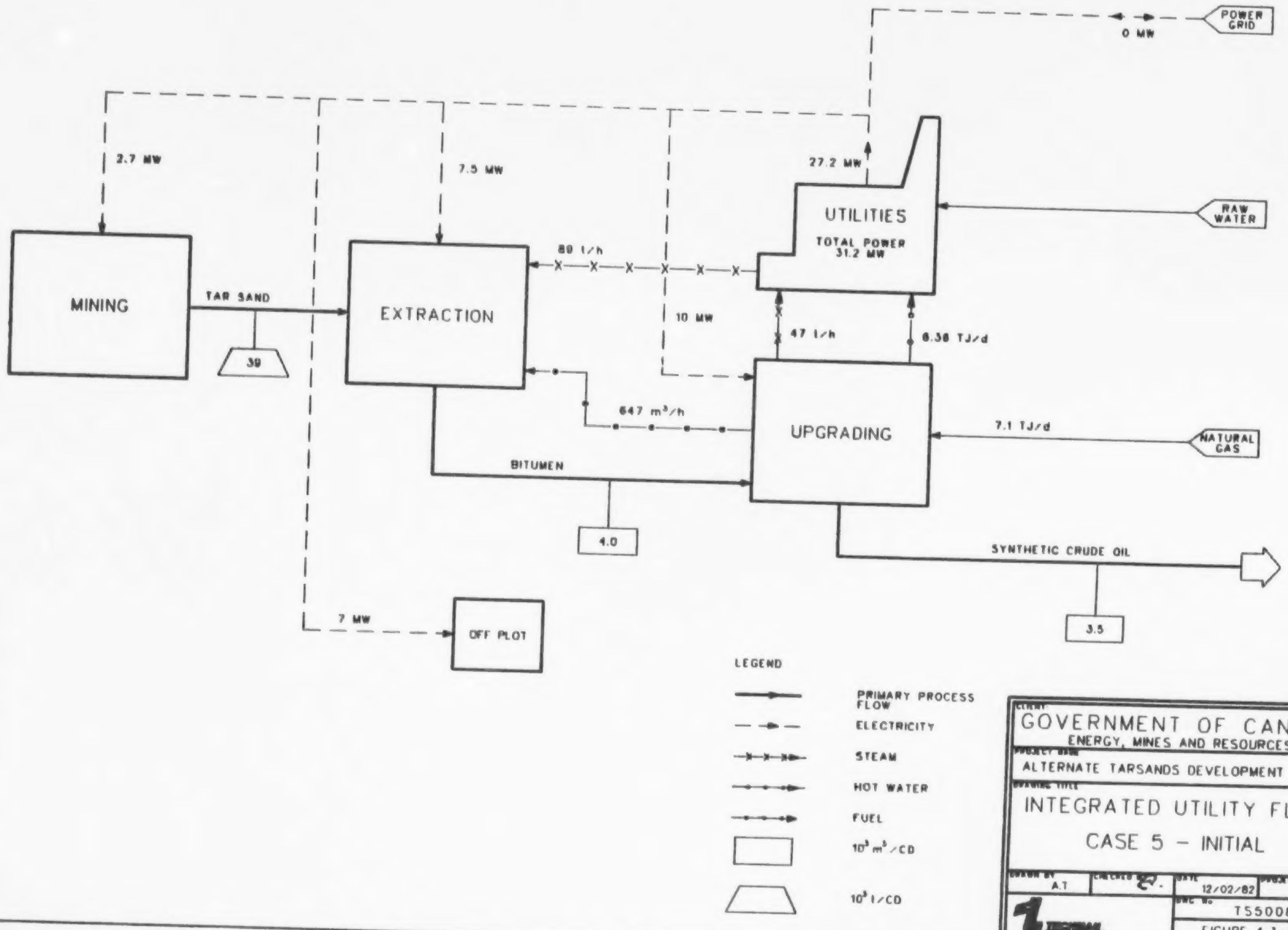
ENERGY, MINES AND RESOURCES

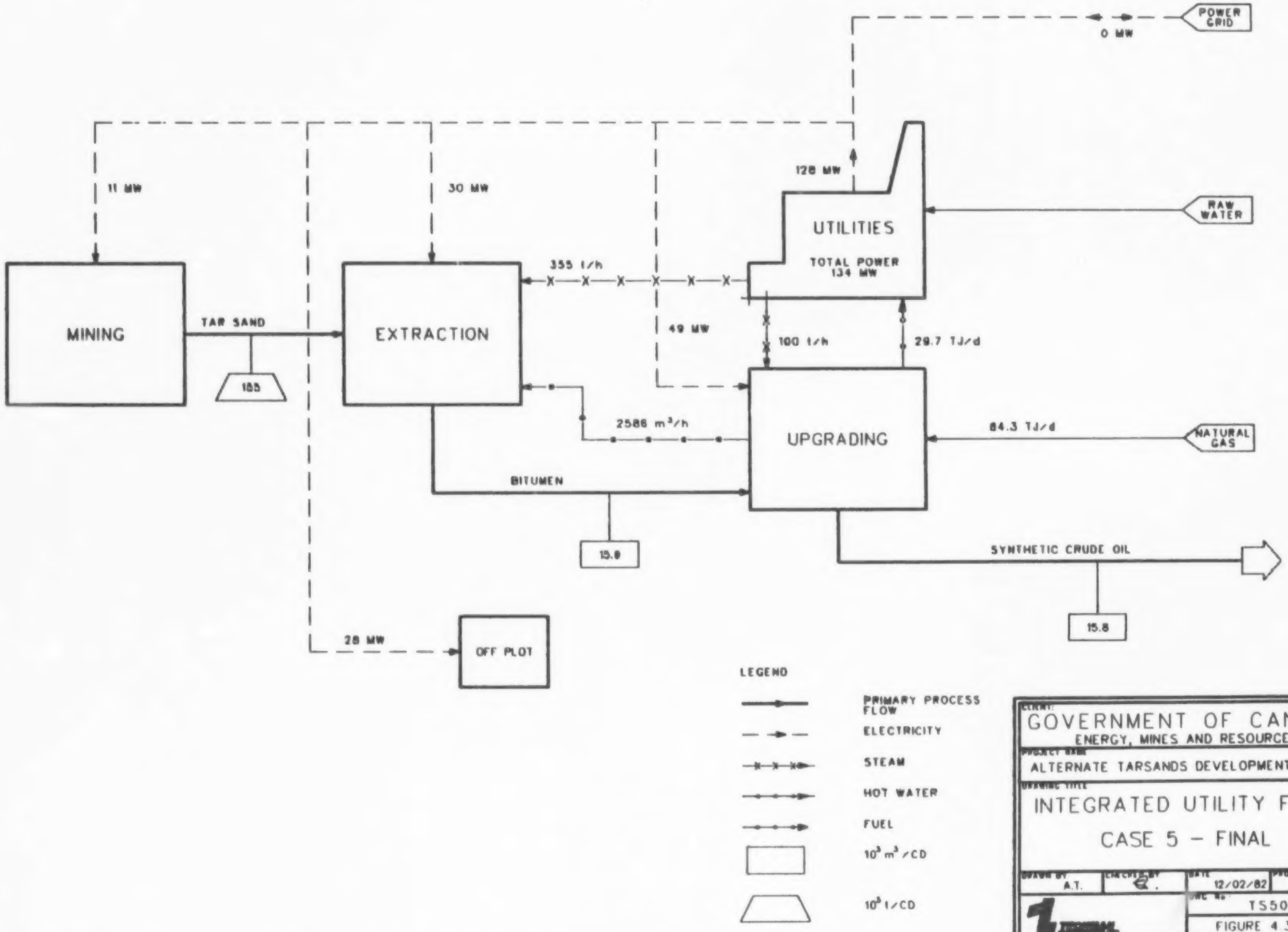
PROJECT NAME: ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE: PROCESS FLOW SUMMARY
CASE 5

DRAWN BY T.F.W.	CHECKED BY	DATE 12/14/82	PROJECT No. TM-500
		DWG No.: TS5008020	
		FIGURE 4.3-9	


POWER GRID
0 MW
2.7 MW
7.5 MW
27.2 MW
UTILITIES
TOTAL POWER 31.2 MW
RAW WATER
MINING
TAR SAND
39
EXTRACTION
80 t/h
10 MW
47 t/h
6.30 TJ/d
647 m³/h
UPGRADING
7.1 TJ/d
NATURAL GAS
BITUMEN
4.0
SYNTHETIC CRUDE OIL
3.5
7 MW
OFF PLOT
LEGEND
PRIMARY PROCESS FLOW
ELECTRICITY
STEAM
HOT WATER
FUEL
10³ m³/CD
10³ t/CD

CLIENT
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE
INTEGRATED UTILITY FLOW
CASE 5 – INITIAL
DRAWN BY A.T
CHECKED
DATE 12/02/82
PROJECT No.
DWG No. TS500809
FIGURE 4 3-10A


POWER GRID
0 MW
11 MW
30 MW
128 MW
RAW WATER
UTILITIES
TOTAL POWER 134 MW
355 t/h
MINING
TAR SAND
185
EXTRACTION
49 MW
100 t/h
29.7 TJ/d
2586 m³/h
UPGRADING
84.3 TJ/d
NATURAL GAS
BITUMEN
15.9
SYNTHETIC CRUDE OIL
15.8
28 MW
OFF PLOT
LEGEND
PRIMARY PROCESS FLOW
ELECTRICITY
STEAM
HOT WATER
FUEL
10³ m³/CD
10³ t/CD

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
INTEGRATED UTILITY FLOW
CASE 5 – FINAL

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A.T.	Q.	12/02/82	

DWG No. TS500810

FIGURE 4.3-10B

The same small fleet of mobile equipment as in Case 3 would be required. As the production requirements increase in Year 6 to Year 11, trucks, hydraulic shovels and other mobile equipment is added to match the fleet of Case 2. The full production configuration is based on two modules operated concurrently. As in Case 2, the modules and the equipment are sized so that one module alone can provide sufficient tarsand to keep the Extraction Plant operating at its capacity.

It has been assumed, that during the initial years of operation a small scale tailings disposal scheme would be developed, such as in Cases 3 and 4, which then could be expanded into a larger scale system, such as in Case 1 and 2 when production reaches 15.9k m^3/CD (100,000 BPCD) of bitumen.

4.3.5.2 Extraction

The extraction process design is based on the K.A. Clark Hot Water Process.

The plant facilities in this case are designed to accommodate expansion up to the final production rating of 15.9 k m^3/CD (100,000 BPCD) of bitumen. The initial phase would include one train of mechanical equipment of the size required to match the equipment in the final two trains. The equipment capacity would be derated by about 20 percent in the initial phase by limiting utilities supplies.

To meet the build-up production requirements, two additional trains of equipment in the Primary Separation and Froth Treatment Plants would be provided. The final mechanical layout would be similar to that discussed in Cases 1 and 2 (Sections 4.3.1.2 and 4.3.2.2, respectively).

4.3.5.3 Upgrading

The upgrader for Case 5 is a staged, or build-up case in which a small Fluid Coker upgrader precedes a larger H-Oil upgrader by about five years. Both upgraders are located adjacent to the mine in the Fort McMurray region.

The initial upgrader, the Fluid Coker, will process 4k m^3/CD (25,000 BPCD) of bitumen with a processing scheme identical to that in Case 3 (Section 4.3.3.3). Only one train of process units is provided which include two Hydrotreaters - one naphtha and one distillate/gas oil - as lead units in the Secondary Upgrader. All imported natural gas (7.1 TJ/CD) is fed to the Hydrogen Production Unit. The synthetic crude oil production is 3.5 k m^3/CD (22,000 BPCD), as in Case 3, and all production is pipelined to the Edmonton area via the assumed expanded AOSPL facilities, again on a tariff basis. All net fluid coke is assumed stockpiled and sulphur is sold on a no value basis.

The second upgrader, the H-Oil Unit, is a hydrogen addition process, licensed by HRI (Hydrocarbon Research Institute). It is designed to process the full 15.9k m^3/CD (100,000 BPCD) of bitumen from the Diluent Recovery Units. The Fluid Coker, or first upgrader, is converted to process the H-Oil bottoms (524+°C); the Secondary Upgrader portion of the first upgrader continues to process fluid coker products and some of the H-Oil products. In addition, a complete new secondary upgrader accompanies the H-Oil primary upgrader.

The ultimate synthetic crude oil production from Case 5 is 15.8k m^3/CD (99,400 BPCD). As in Case 1, synthetic crude oil is delivered to Edmonton via the assumed expanded AOSPL facilities on a tariff basis. Net coke and sulphur are disposed of as in the initial phase of Case 5 above. Natural gas imports for the second phase of Case 5 are the highest so far at 64.3 TJ/CD, due in part to the increased hydrogen requirements to date plus the reduced steam export from upgrading.

4.3.5.4 Utilities

The configuration of utilities is again identical to Case 1, except that the system is built in two phases.

For the initial phase, the utility balances are similiar to Case 3. The installed capacity for the phase is 150 t/h of steam and 64 MW of electricity.

For the final phase, however, the steam balances are somewhat different from Case 1 or 2 as upgrading due to H-Oil process is now net importer of steam from the Utility Plant.

As a consequence, the boiler capacity of the Utility Plant is much greater.

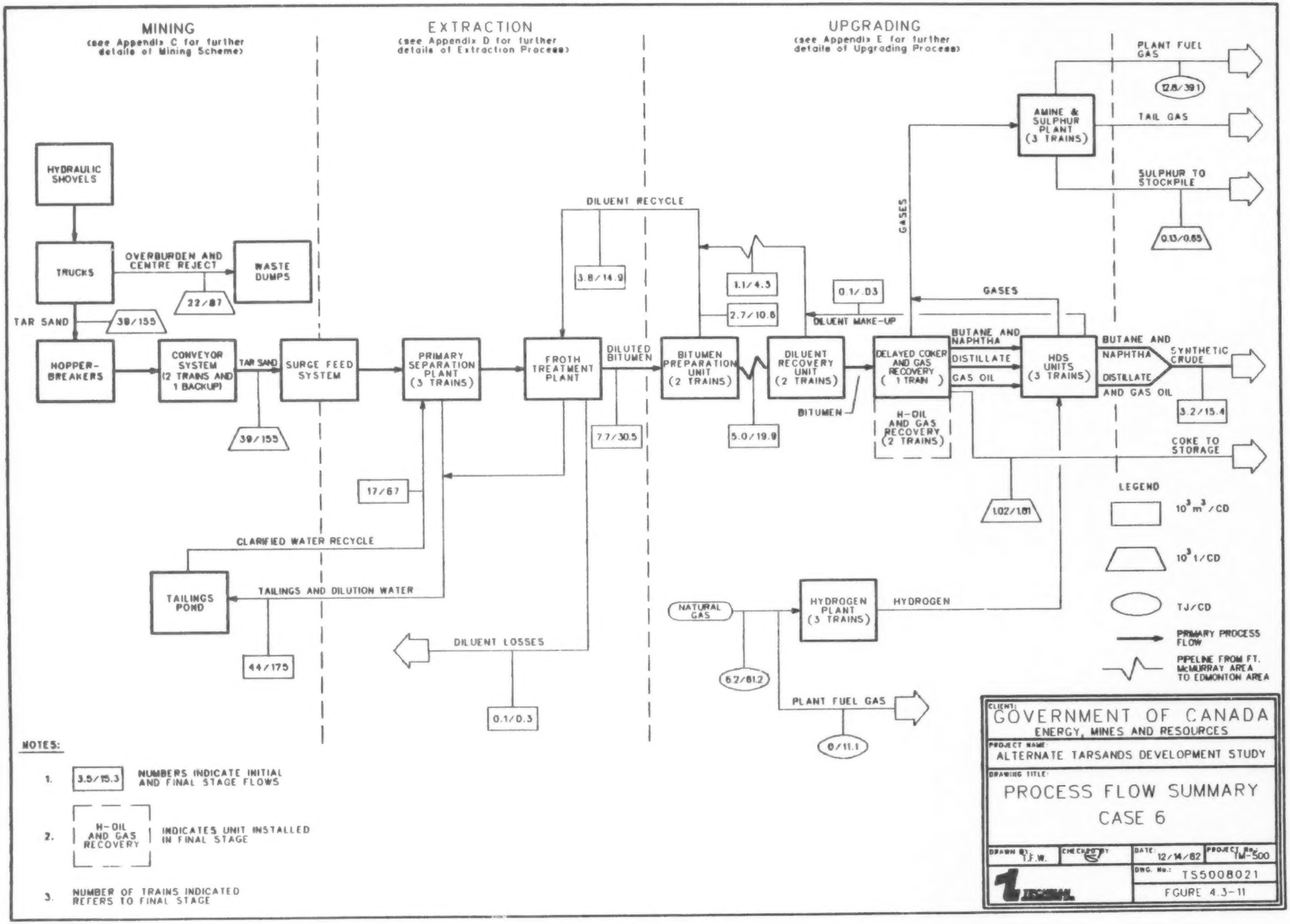
The installed capacity of the Utility Plant for the final phase is 1350 t/h of steam and 198 MW of electricity.

4.3.5.5 General and Off-Plot Areas

The general off-plot area requirements for Case 5 are as described for Case 1 (Section 4.3.1.5).

4.3.6 Case 6

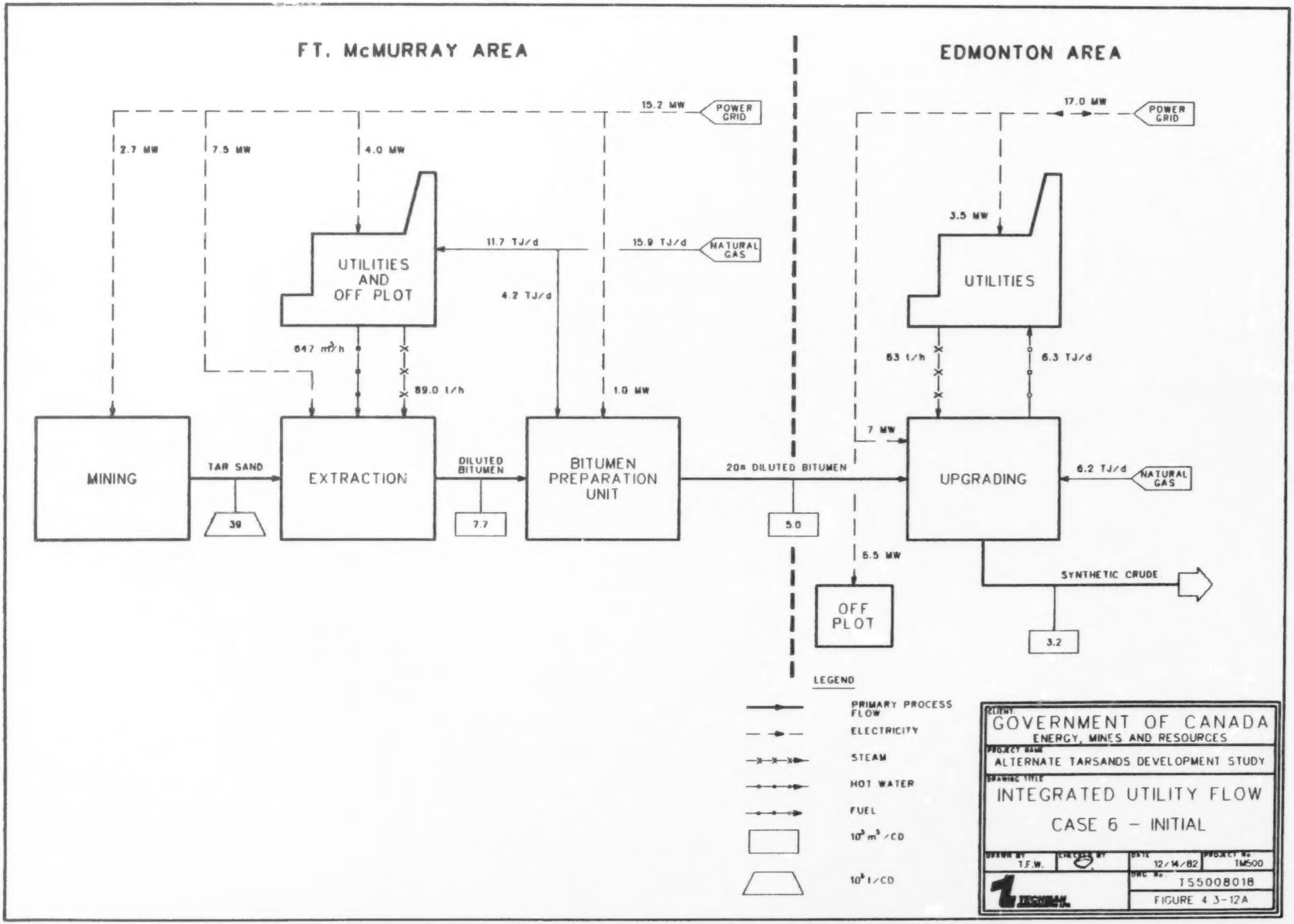
Case 6 is identical in concept with Case 5, except that the upgrading facilities would be located remote from the mining/extraction operations, thereby making energy integration impossible, and the primary upgrading process is Delayed Coking rather than Fluid Coking. A separate Utility Plant, supplying steam only, is required at the Extraction Plant. In this scheme, all electrical power is purchased. A process flow summary and an integrated utility flow summary for case 6 are shown in Figures 4.3-11 and 4.3-12, respectively.


MINING
(see Appendix C for further details of Mining Scheme)
EXTRACTION
(see Appendix D for further details of Extraction Process)
UPGRADING
(see Appendix E for further details of Upgrading Process)
HYDRAULIC SHOVELS
TRUCKS
OVERBURDEN AND CENTRE REJECT
WASTE DUMPS
22/87
TAR SAND
38/155
HOPPER-BREAKERS
CONVEYOR SYSTEM (2 TRAINS AND 1 BACKUP)
TAR SAND
38/155
SURGE FEED SYSTEM
PRIMARY SEPARATION PLANT (3 TRAINS)
17/67
CLARIFIED WATER RECYCLE
TAILINGS POND
TAILINGS AND DILUTION WATER
44/175
FROTH TREATMENT PLANT
DILUENT RECYCLE
3.8/14.9
DILUTED BITUMEN
7.7/30.5
DILUENT LOSSES
0.1/0.3
BITUMEN PREPARATION UNIT (2 TRAINS)
1.1/4.3
2.7/10.6
5.0/19.9
DILUENT RECOVERY UNIT (2 TRAINS)
0.1/.03
DILUENT MAKE-UP
BITUMEN
DELAYED COKER AND GAS RECOVERY (1 TRAIN)
H-OIL AND GAS RECOVERY (2 TRAINS)
GASES
GASES
BUTANE AND NAPHTHA
DISTILLATE
GAS OIL
HDS UNITS (3 TRAINS)
AMINE & SULPHUR PLANT (3 TRAINS)
PLANT FUEL GAS
12.8/39.1
TAIL GAS
SULPHUR TO STOCKPILE
0.13/0.85
BUTANE AND NAPHTHA
DISTILLATE AND GAS OIL
SYNTHETIC CRUDE
3.2/15.4
COKE TO STORAGE
1.02/1.81
NATURAL GAS
6.2/81.2
HYDROGEN PLANT (3 TRAINS)
HYDROGEN
PLANT FUEL GAS
0/11.1
LEGEND
$10^3 m^3$/CD
10^3 1/CD
TJ/CD
PRIMARY PROCESS FLOW
PIPELINE FROM FT. McMURRAY AREA TO EDMONTON AREA

NOTES:

1. 3.5/15.3 NUMBERS INDICATE INITIAL AND FINAL STAGE FLOWS
2. H-OIL AND GAS RECOVERY INDICATES UNIT INSTALLED IN FINAL STAGE
3. NUMBER OF TRAINS INDICATED REFERS TO FINAL STAGE

CLIENT: GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME: ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE: PROCESS FLOW SUMMARY
CASE 6
DRAWN BY: T.F.W.
CHECKED BY:
DATE: 12/14/82
PROJECT No.: TM-500
DWG. No.: TS5008021
FGURE 4.3-11


FT. McMURRAY AREA
EDMONTON AREA
15.2 MW
POWER GRID
2.7 MW
7.5 MW
4.0 MW
UTILITIES AND OFF PLOT
11.7 TJ/d
15.9 TJ/d
NATURAL GAS
4.2 TJ/d
647 m³/h
89.0 t/h
1.0 MW
MINING
TAR SAND
39
EXTRACTION
DILUTED BITUMEN
7.7
BITUMEN PREPARATION UNIT
20% DILUTED BITUMEN
5.0
17.0 MW
POWER GRID
3.5 MW
UTILITIES
63 t/h
6.3 TJ/d
7 MW
UPGRADING
6.2 TJ/d
NATURAL GAS
6.5 MW
OFF PLOT
SYNTHETIC CRUDE
3.2
LEGEND
PRIMARY PROCESS FLOW
ELECTRICITY
STEAM
HOT WATER
FUEL
10³ m³/CD
10³ t/CD

CLIENT GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME ALTERNATE TARSANDS DEVELOPMENT STUDY

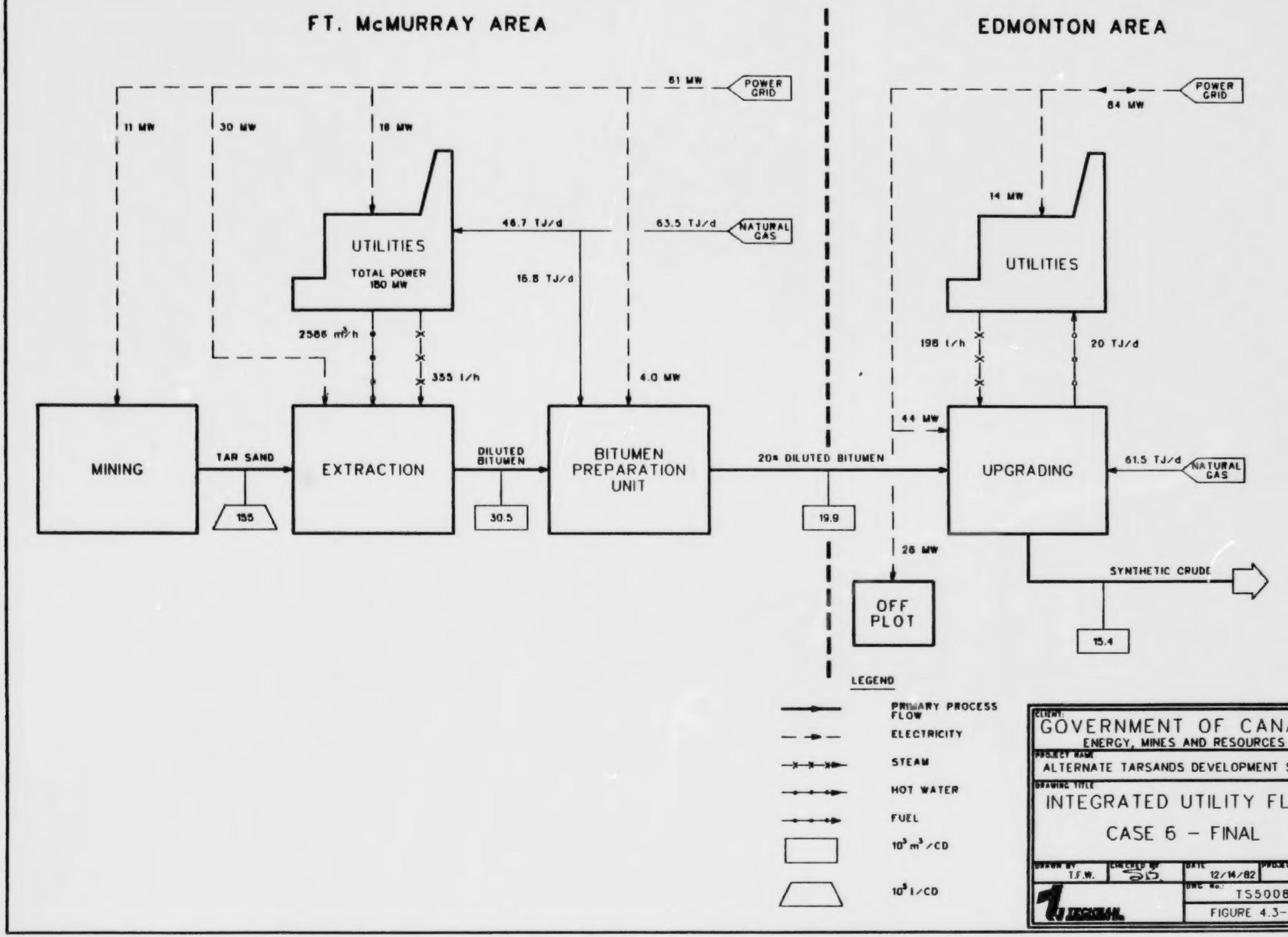
DRAWING TITLE INTEGRATED UTILITY FLOW

CASE 6 – INITIAL

DRAWN BY	CHECKED BY	DATE	PROJECT No.
T.F.W.		12/14/82	TM500

DWG. No. TS5008018

FIGURE 4.3-12A


FT. McMURRAY AREA
EDMONTON AREA
POWER GRID
61 MW
11 MW
30 MW
18 MW
UTILITIES
TOTAL POWER 180 MW
NATURAL GAS
46.7 TJ/d
63.5 TJ/d
16.8 TJ/d
2586 m³/h
355 t/h
4.0 MW
MINING
TAR SAND
155
EXTRACTION
DILUTED BITUMEN
30.5
BITUMEN PREPARATION UNIT
20% DILUTED BITUMEN
19.9
POWER GRID
84 MW
14 MW
UTILITIES
198 t/h
20 TJ/d
44 MW
UPGRADING
61.5 TJ/d
NATURAL GAS
26 MW
OFF PLOT
SYNTHETIC CRUDE
15.4
LEGEND
PRIMARY PROCESS FLOW
ELECTRICITY
STEAM
HOT WATER
FUEL
10³ m³/CD
10³ t/CD

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
INTEGRATED UTILITY FLOW
CASE 6 – FINAL

DRAWN BY	CHECKED BY	DATE	PROJECT No.:
T.F.W.	S.S.	12/14/82	TM500

TECHMAN

DWG No.: TS5008019

FIGURE 4.3-12B

The significant difference between this case and the base case is that the ultimate capacity is achieved in two steps, the primary upgrading technology in the final configuration is based on hydrogen addition rather than carbon rejection, and the selected mining technology is mobile equipment. Additionally, the upgrader is located in the Fort Saskatchewan area and is, therefore, not energy-integrated with the mining/extraction facilities. No electrical power is generated in this case, but steam is generated at both the upgrader and the Extraction Plant.

4.3.6.1 Mining

The mining scheme for Case 6 is an exact duplication of Case 5, as it was assumed that remoteness of the upgrading facilities will have no impact on the method of mining.

4.3.6.2 Extraction

The extraction process design is based on the K.A. Clark Hot Water Process.

The extraction plant facilities would be constructed in the same staged manner as described in Case 5 (Section 4.3.5.2). The significant differences in this case from Case 5 are in the utilities steam supply system which is required for conditioning and water heating, as no waste heat is available from the remotely located upgrader.

4.3.6.3 Upgrading

The upgrader in Case 6 is remote from the mine site. It is assumed located in the Edmonton area. This is the major difference between Cases 5 and 6.

The second difference is the need for a Bitumen Preparation Unit (BPU) at the mine site. The BPU is needed to facilitate pumping bitumen with minimum diluent from the mine site to the Edmonton area. Diluent concentration is reduced from 48 to 20 percent by volume for pipelining. The third difference with Case 5 is that the initial upgrader is Delayed Coking, instead of Fluid Coking.

The Delayed Coker, with its secondary upgrading units, precedes the construction of the H-Oil upgrader by about five years. The coker processes 4k m^3/CD (25,000 BPCD) of bitumen feed and produces 3.2k m^3/CD (20,100 BPCD) of synthetic crude oil during the initial five years. Product coke and sulphur are assumed sold at no net value.

The final upgrader consists of an H-Oil Primary Upgrader with its secondary upgrading units plus the initial Delayed Coker upgrader expanded to accept H-Oil bottoms. The H-Oil unit will process the full 15.9k m^3/CD (100,000 BPCD) of bitumen feed; the combined upgrader produces a total of 15.4k m^3/CD (96,900 BPCD) of synthetic crude oil product.

In the final stage, the original Delayed Coker is expanded to process H-Oil bottoms (524+°C). The coker's secondary upgrading units continue to be used in the final stage to treat a blend of coker and H-Oil products.

The H-Oil Primary Upgrader is comprised of two trains, each with two parallel reactors. Its associated Secondary Upgrader is also comprised of two trains, each of which is headed by two Hydro Desulphurization units - naphtha and distillate/gas oil.

The combination of additional process units at the mine site (BPU's and the Delayed Coking Upgrader) necessitates the largest gas imports of any case. Roughly 50 percent of the gas imports is required at the mine site to satisfy the Extraction Plant and the BPU's heat requirements.

Product coke and sulphur are assumed to be sold at no net value in the Edmonton area.

4.3.6.4 Utilities

The concept of the utility design for this case is radically different from the previous cases, as the utility system can no longer be integrated due to the geographical separation of mining and extraction from upgrading.

As a consequence, a large quantity of energy required to heat extraction water is no longer available from upgrading and must be supplied by the Utility Plant. A separate Utility Plant is provided at each location.

For the mining/extraction complex in the Fort McMurray area, the Utility Plant supplies the Extraction Plant with low pressure steam and hot water which is produced from high pressure wet steam generated by once-through oil field steam generators.

The once-through steam generators require less water treatment than the conventional boilers and, therefore, are more suitable for the applications where a large quantity of make-up water is required. Fuel for the plant is natural gas.

Electricity for the complex is supplied from the AIS through a tie-line, with no internal power generation.

For the upgrading complex in the Edmonton area, the Utility Plant again supplies steam only to the process areas and electricity is imported from the AIS.

The upgrading area for this case is also a net importer for both initial and final phase.

The conventional high pressure packaged boilers will be installed with the plant gas as fuel.

The Utility Plant includes a make-up water treatment plant and compressed air system.

Installed capacity of the Utility Plant for each location is as follows:

Mining/Extraction Complex in Fort McMurray area:
   Initial - 320 t/h of steam
   Final - 1120 t/h of steam

Upgrading Complex in Edmonton area;
   Initial - 200 t/h of steam
   Final - 400 t/h of steam

4.3.6.5 General and Off-Plot Areas

The general and off-plot area requirements for Case 6 are as described for Case 1 (Section 4.3.1.5).

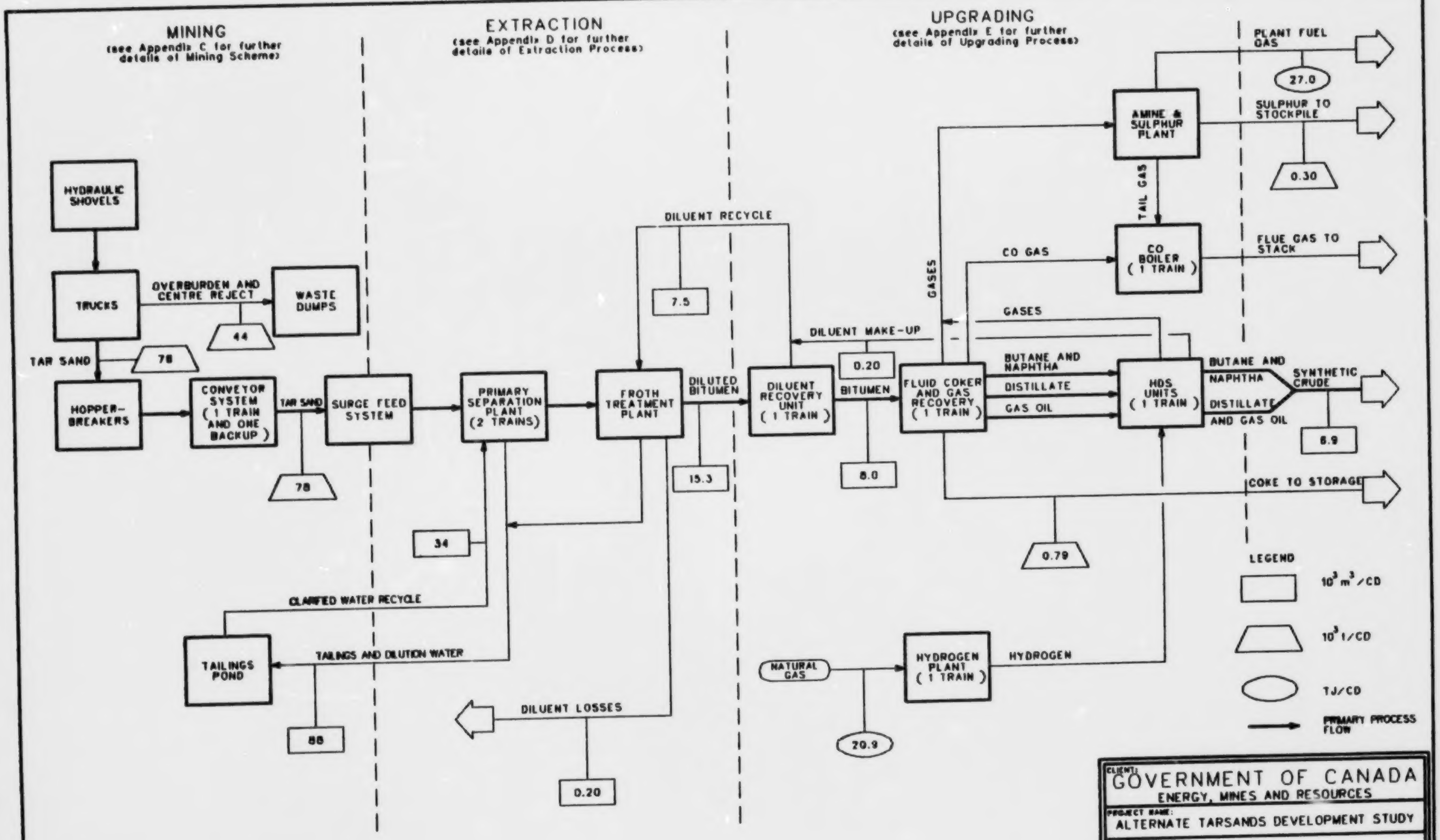
4.3.7 Case 7

Case 7 is essentially identical to Case 2, except that the sizing is based on 8k m^3/CD (50,000 BPCD) of extracted bitumen, and there is only one train of upgrading. A process flow summary and an integrated utility flow summary for Case 7 are shown in Figures 4.3-13 and 4.3-14, respectively.

The significant difference between this case and the base case is the selection of mobile mining equipment, and the size is half of the base case with only one train of process units.

4.3.7.1 Mining

The truck and shovel mining scheme in Case 7 is similar to that for Case 2 and Case 3 and has been developed for the 8k m^3/CD (50,000 BPCD) of

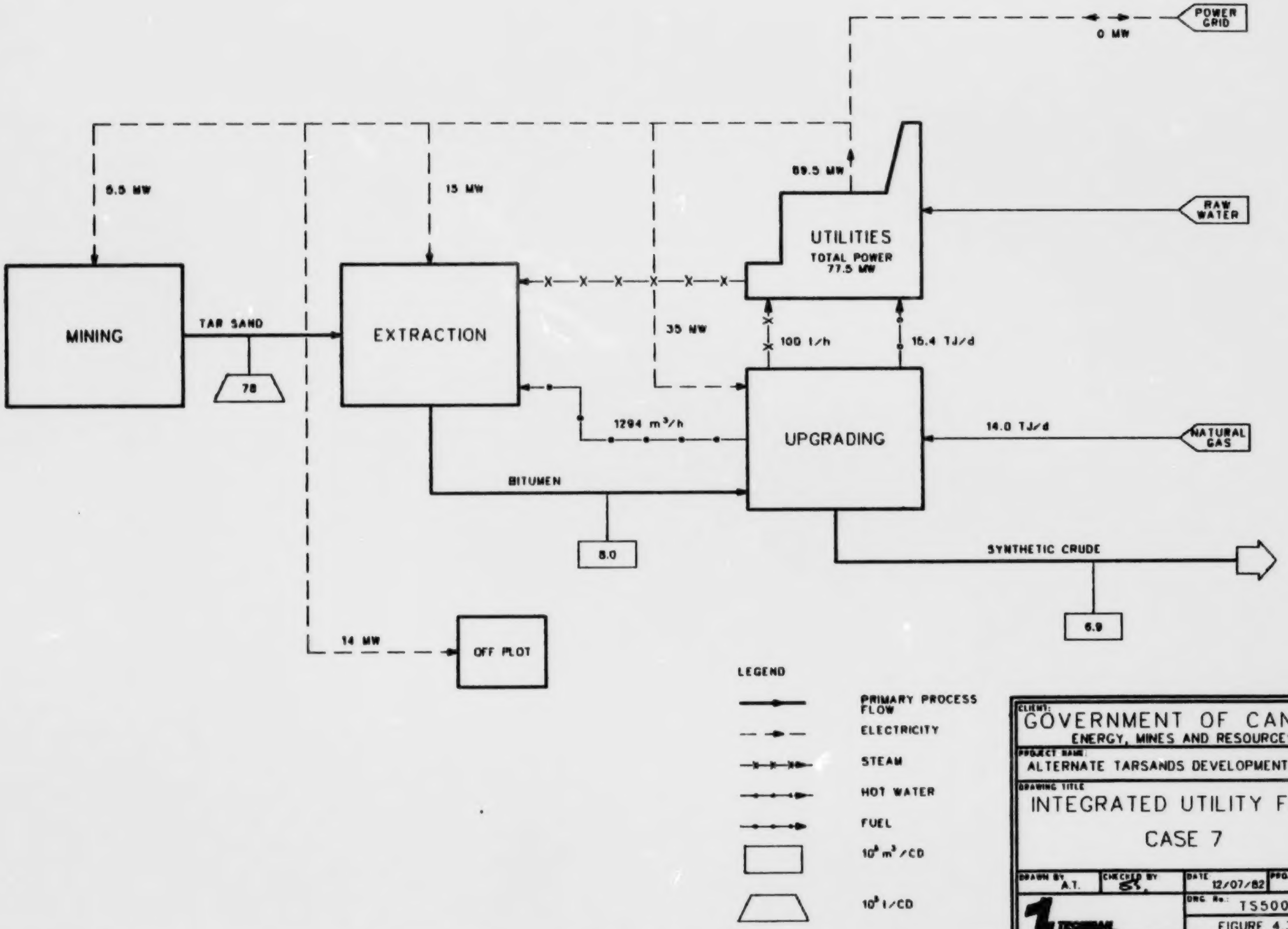

MINING
(see Appendix C for further details of Mining Scheme)
EXTRACTION
(see Appendix D for further details of Extraction Process)
UPGRADING
(see Appendix E for further details of Upgrading Process)
HYDRAULIC SHOVELS
TRUCKS
OVERBURDEN AND CENTRE REJECT
44
WASTE DUMPS
TAR SAND
78
HOPPER-BREAKERS
CONVEYOR SYSTEM (1 TRAIN AND ONE BACKUP)
TAR SAND
78
SURGE FEED SYSTEM
PRIMARY SEPARATION PLANT (2 TRAINS)
34
FROTH TREATMENT PLANT
DILUENT RECYCLE
7.5
DILUTED BITUMEN
15.3
DILUENT RECOVERY UNIT (1 TRAIN)
DILUENT MAKE-UP
0.20
BITUMEN
8.0
FLUID COKER AND GAS RECOVERY (1 TRAIN)
GASES
CO GAS
GASES
BUTANE AND NAPHTHA
DISTILLATE
GAS OIL
HDS UNITS (1 TRAIN)
BUTANE AND NAPHTHA
DISTILLATE AND GAS OIL
SYNTHETIC CRUDE
8.9
COKE TO STORAGE
0.79
AMINE & SULPHUR PLANT
TAIL GAS
CO BOILER (1 TRAIN)
PLANT FUEL GAS
27.0
SULPHUR TO STOCKPILE
0.30
FLUE GAS TO STACK
CLARIFIED WATER RECYCLE
TAILINGS AND DILUTION WATER
TAILINGS POND
88
DILUENT LOSSES
0.20
NATURAL GAS
20.9
HYDROGEN PLANT (1 TRAIN)
HYDROGEN
LEGEND
10³ m³/CD
10³ t/CD
TJ/CD
PRIMARY PROCESS FLOW

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
PROCESS FLOW SUMMARY
CASE 7

DRAWN BY: T.F.W.	CHECKED BY: EK.	DATE: 12/13/82	PROJECT No.:
		DWG. No.: TS5008028	
		FIGURE 4 3-13	


POWER GRID
0 MW
69.5 MW
6.5 MW
15 MW
UTILITIES
TOTAL POWER 77.5 MW
RAW WATER
MINING
TAR SAND
78
EXTRACTION
35 MW
100 t/h
15.4 TJ/d
1294 m³/h
UPGRADING
14.0 TJ/d
NATURAL GAS
BITUMEN
8.0
SYNTHETIC CRUDE
6.9
14 MW
OFF PLOT
LEGEND
PRIMARY PROCESS FLOW
ELECTRICITY
STEAM
HOT WATER
FUEL
10³ m³/CD
10³ l/CD

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
INTEGRATED UTILITY FLOW
CASE 7

DRAWN BY	CHECKED BY	DATE	PROJECT No.
A.T.	SS.	12/07/82	TM-500

DRG No.: TS5008023

FIGURE 4.3-14

bitumen operation. The mining scheme selection was based on cost trends indicated in a comparison of the first four cases.

The mine layout is identical to one half of that shown for Case 2 (Appendix C). The modules located closest to the Extraction Plant form the 8k m^3/CD (50,000 BPCD) bitumen mine. Only one module would be mined at a time.

4.3.7.2 Extraction

The extraction process design is based on the K.A. Clark Hot Water Process.

The feed surge area has capital allowances in both the mine and extraction areas to allow effective materials handling of the tarsand feed requirements for the Primary Separation Plant.

The Primary Separation and Froth Treatment Plants would be designed as two trains of equipment similar in size to that required in Cases 3 and 4.

4.3.7.3 Upgrading

The site location and general process configuration for the Case 7 Upgrader are identical to those described for Case 1 (Section 4.3.1.3). However, the major differences with Case 1 are:

- one upgrader train only is provided;
- capacity is halved, to 8k m^3/CD (50,000 BPCD) of bitumen feed; and
- yield of synthetic crude oil is halved to 6.9k m^3/CD (43,400 BPCD) of bitumen feed.

A review of this case is intended to investigate sensitivities to upgrader size when compared to other fluid coker upgrading cases.

4.3.7.4 Utilities

This case is identical to Case 2 in all respects except the capacity is one half of Case 2 (Section 4.3.2.4).

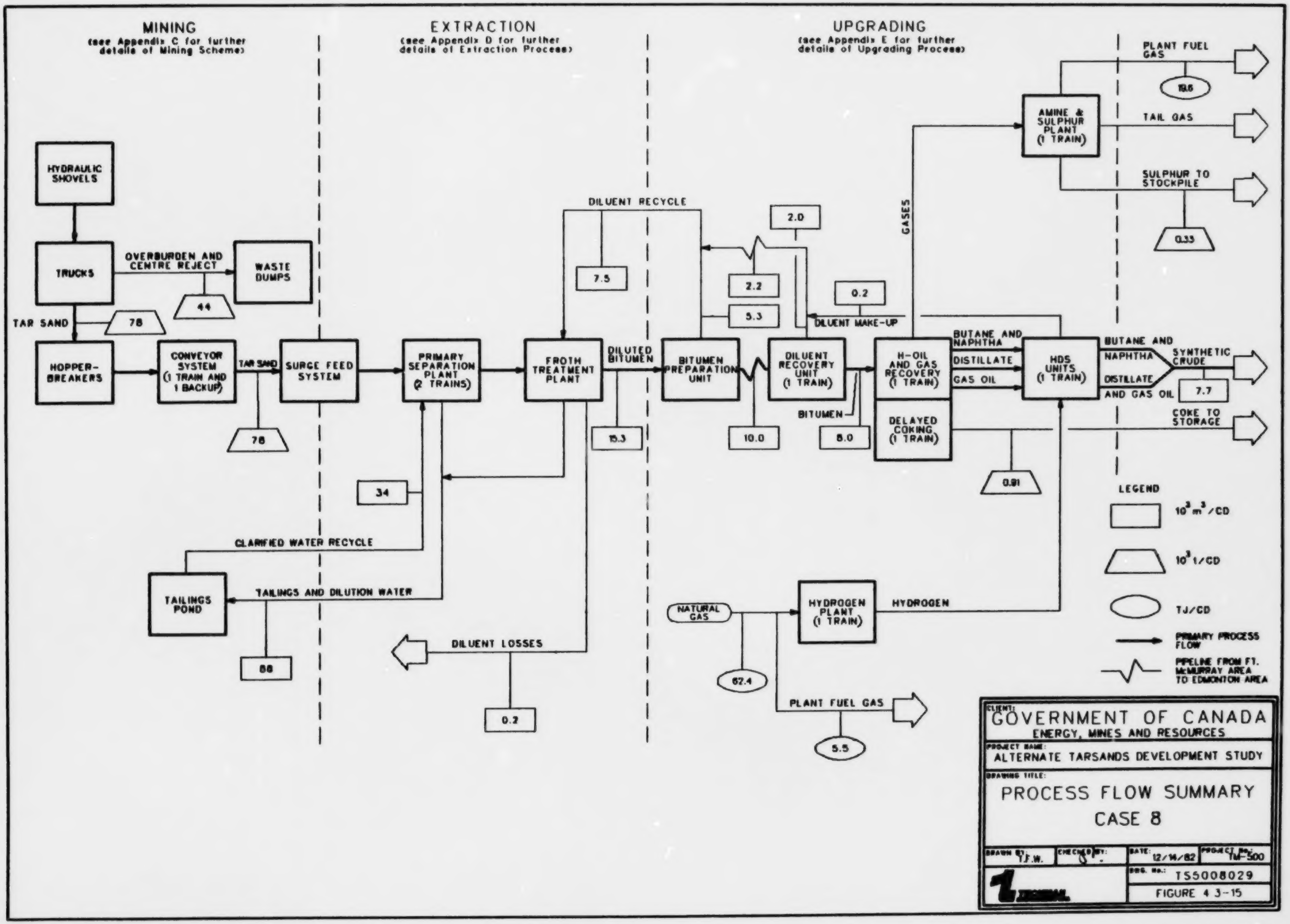
4.3.7.5 General and Off-Plot Areas

The general and off-plot area requirements for Case 7 are as described for Case 1 (Section 4.3.1.5)

4.3.8 Case 8

Case 8 is identical to Case 7 except that the upgrading process is assumed to be remote from the mining/extraction facility, the primary upgrading processes are a combination of an H-Oil/Delayed Coking configuration (single-train); the lack of energy integration necessitates the provision of steam generation at the lease. There is no staging and all facilities are assumed to be installed at the same time. It is also assumed that any required electrical power would be purchased. A process flow summary and an integrated utility flow summary for Case 8 are shown in Figures 4.3-15 an 4.3-16, respectively.

The significant difference between this case and the base case is that the size is one-half of the base, the upgrader is located remote from the mining/extraction unit, and is not energy-integrated with the facilities on the lease. Mobile equipment has been selected for the mining operations. Additionally, the upgrader is located in the Fort Saskatchewan area and steam is generated at both the lease and the upgrader site. All electrical power is purchased.

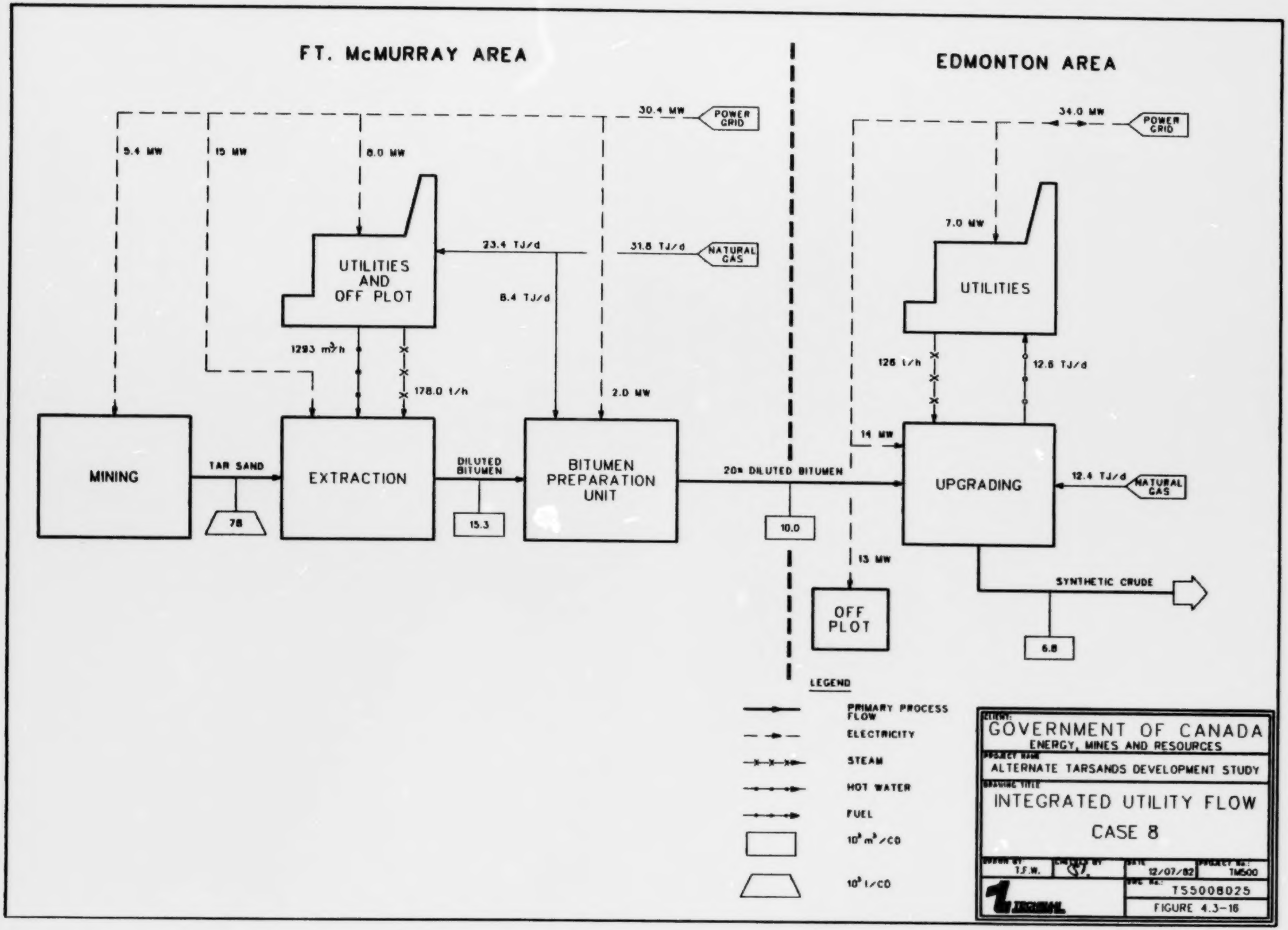

MINING
(see Appendix C for further details of Mining Scheme)
EXTRACTION
(see Appendix D for further details of Extraction Process)
UPGRADING
(see Appendix E for further details of Upgrading Process)
HYDRAULIC SHOVELS
TRUCKS
OVERBURDEN AND CENTRE REJECT
44
WASTE DUMPS
TAR SAND
78
HOPPER-BREAKERS
CONVEYOR SYSTEM (1 TRAIN AND 1 BACKUP)
TAR SAND
78
SURGE FEED SYSTEM
PRIMARY SEPARATION PLANT (2 TRAINS)
34
CLARIFIED WATER RECYCLE
TAILINGS AND DILUTION WATER
TAILINGS POND
88
FROTH TREATMENT PLANT
DILUENT RECYCLE
7.5
DILUTED BITUMEN
15.3
DILUENT LOSSES
0.2
BITUMEN PREPARATION UNIT
2.2
5.3
2.0
10.0
DILUENT RECOVERY UNIT (1 TRAIN)
0.2
DILUENT MAKE-UP
BITUMEN
8.0
GASES
H-OIL AND GAS RECOVERY (1 TRAIN)
DELAYED COKING (1 TRAIN)
BUTANE AND NAPHTHA
DISTILLATE
GAS OIL
HDS UNITS (1 TRAIN)
0.81
AMINE & SULPHUR PLANT (1 TRAIN)
PLANT FUEL GAS
18.6
TAIL GAS
SULPHUR TO STOCKPILE
0.33
BUTANE AND NAPHTHA
DISTILLATE AND GAS OIL
SYNTHETIC CRUDE
7.7
COKE TO STORAGE
NATURAL GAS
62.4
HYDROGEN PLANT (1 TRAIN)
HYDROGEN
PLANT FUEL GAS
5.5
LEGEND
$10^3 m^3$/CD
10^3 t/CD
TJ/CD
PRIMARY PROCESS FLOW
PIPELINE FROM FT. McMURRAY AREA TO EDMONTON AREA

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
PROCESS FLOW SUMMARY
CASE 8

DRAWN BY: T.F.W.	CHECKED BY:	DATE: 12/14/82	PROJECT No.: TM-500
		DWG. No.: TS5008029	
		FIGURE 4 3-15	


FT. McMURRAY AREA
EDMONTON AREA
POWER GRID
30.4 MW
9.4 MW
15 MW
8.0 MW
NATURAL GAS
31.8 TJ/d
23.4 TJ/d
8.4 TJ/d
UTILITIES AND OFF PLOT
1293 m³/h
178.0 t/h
2.0 MW
MINING
TAR SAND
78
EXTRACTION
DILUTED BITUMEN
15.3
BITUMEN PREPARATION UNIT
20% DILUTED BITUMEN
10.0
POWER GRID
34.0 MW
7.0 MW
UTILITIES
126 t/h
12.6 TJ/d
14 MW
UPGRADING
12.4 TJ/d
NATURAL GAS
13 MW
OFF PLOT
SYNTHETIC CRUDE
6.8
LEGEND
PRIMARY PROCESS FLOW
ELECTRICITY
STEAM
HOT WATER
FUEL
10³ m³/CD
10³ t/CD

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
INTEGRATED UTILITY FLOW
CASE 8

DRAWN BY	CHECKED BY	DATE	PROJECT No.
T.F.W.		12/07/82	TM500
		DWG No.	TS5008025
TECHMAN			FIGURE 4.3-16

4.3.8.1 Mining

The mining scheme for Case 8 is an exact duplication of Case 7, as it was assumed that remoteness of the upgrading facilities will have no impact on the method of mining.

4.3.8.2 Extraction

The extraction process design and mechanical equipment requirements are the same as that required in Case 7.

The significant differences in this case relate to the supply from the Utility Plant of steam required for conditioning and water heating as no waste heat is available from the remotely located upgrader.

4.3.8.3 Upgrading

Sensitivity to size and investment timing with the upgrader is also investigated in Case 8.

An 8k m^3 (50,000 BPCD) bitumen feed upgrader, remote from the mine site and comprising of a one H-Oil/Delayed Coker train is assumed. The entire upgrader is installed at one time (no staging). This offers an advantage over Case 6 final in that the Secondary Upgrader can be combined for processing both the Coker and the H-Oil products simultaneously. Therefore, only one train of process units is required.

Product yields and gas imports are one-half of those identified in Case 6 final. In addition, the diluted bitumen from the Bitumen Preparation Unit is assumed transported to the Edmonton area Upgrader via the expanded AOSPL facilities on a tariff basis. The solvent recovered in the Edmonton area is returned to the mine site, via a new pipeline, also on a tariff basis.

4.3.8.4 Utilities

This case is similiar to Case 6 in that mining/extraction is located in the Fort McMurray area and a remote upgrader is located in the Edmonton area. The concept of Utility Plants for both locations is identical to Case 6.

Steam and hot water is produced in the Utility Plant and electricity is entirely imported from the grid.

Installed capacities are:

Mining//Extraction	- 640 t/h of steam
Upgrading	- 300 t/h of steam

4.3.8.5 General and Off-Plot Areas

The general and off-plot area requirements for Case 8 are as described for Case 1 (Section 4.3.1.5).

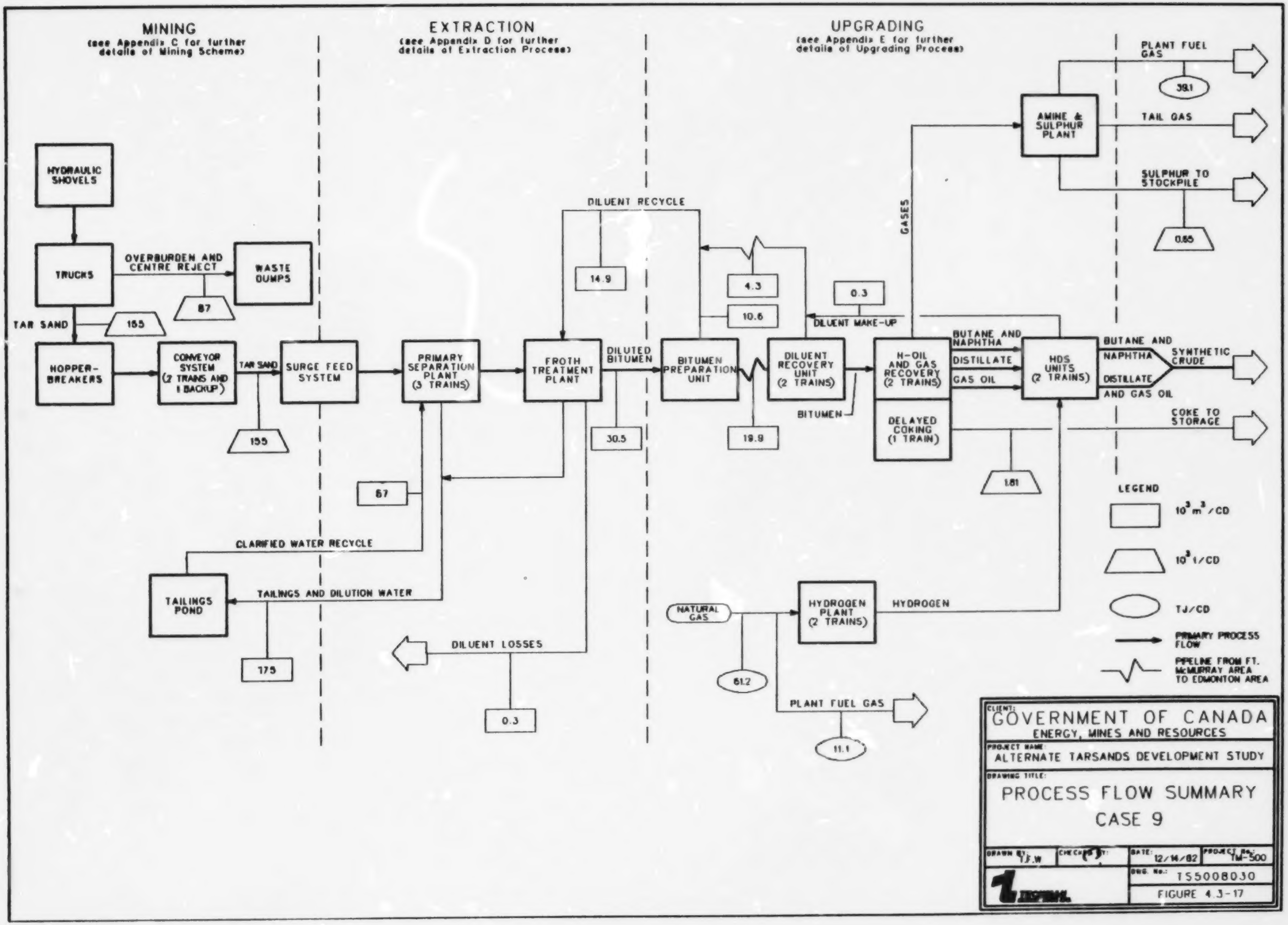
4.3.9 Case 9

Case 9 is identical to Case 8, except that it is based on 15.9k m^3/CD (100,000 BPCD) of extracted bitumen. A process flow summary and an integrated utility flow for Case 9 are shown in Figures 4.3-17 and 4.3-18, respectively.

The significant difference between this case and the base case is that the primary upgrading technology is based on hydrogen addition rather than carbon rejection and the selected mining technology is mobile equipment. Additionally, the upgrader is located in the Fort Saskatchewan area and is, therefore, not energy-integrated with the on-lease facilities. All electrical power is purchased and steam is generated at both the upgrader and the extraction facilities.

4.3.9.1 Mining

The mining scheme for Case 9 is an exact duplicaton of Case 2, as it was assumed that remoteness of the upgrading facilities will have no impact on the method of mining.


MINING
(see Appendix C for further details of Mining Scheme)
EXTRACTION
(see Appendix D for further details of Extraction Process)
UPGRADING
(see Appendix E for further details of Upgrading Process)
HYDRAULIC SHOVELS
TRUCKS
OVERBURDEN AND CENTRE REJECT
WASTE DUMPS
87
TAR SAND
155
HOPPER-BREAKERS
CONVEYOR SYSTEM (2 TRAINS AND 1 BACKUP)
TAR SAND
155
SURGE FEED SYSTEM
PRIMARY SEPARATION PLANT (3 TRAINS)
67
CLARIFIED WATER RECYCLE
TAILINGS AND DILUTION WATER
TAILINGS POND
175
FROTH TREATMENT PLANT
DILUENT RECYCLE
14.9
DILUTED BITUMEN
30.5
DILUENT LOSSES
0.3
BITUMEN PREPARATION UNIT
4.3
10.6
19.9
DILUENT RECOVERY UNIT (2 TRAINS)
0.3
DILUENT MAKE-UP
BITUMEN
H-OIL AND GAS RECOVERY (2 TRAINS)
DELAYED COKING (1 TRAIN)
GASES
BUTANE AND NAPHTHA
DISTILLATE
GAS OIL
1.81
HDS UNITS (2 TRAINS)
AMINE & SULPHUR PLANT
PLANT FUEL GAS
39.1
TAIL GAS
SULPHUR TO STOCKPILE
0.85
BUTANE AND NAPHTHA
DISTILLATE AND GAS OIL
SYNTHETIC CRUDE
COKE TO STORAGE
NATURAL GAS
61.2
HYDROGEN PLANT (2 TRAINS)
HYDROGEN
PLANT FUEL GAS
11.1
LEGEND
10³m³/CD
10³t/CD
TJ/CD
PRIMARY PROCESS FLOW
PIPELINE FROM FT. McMURRAY AREA TO EDMONTON AREA

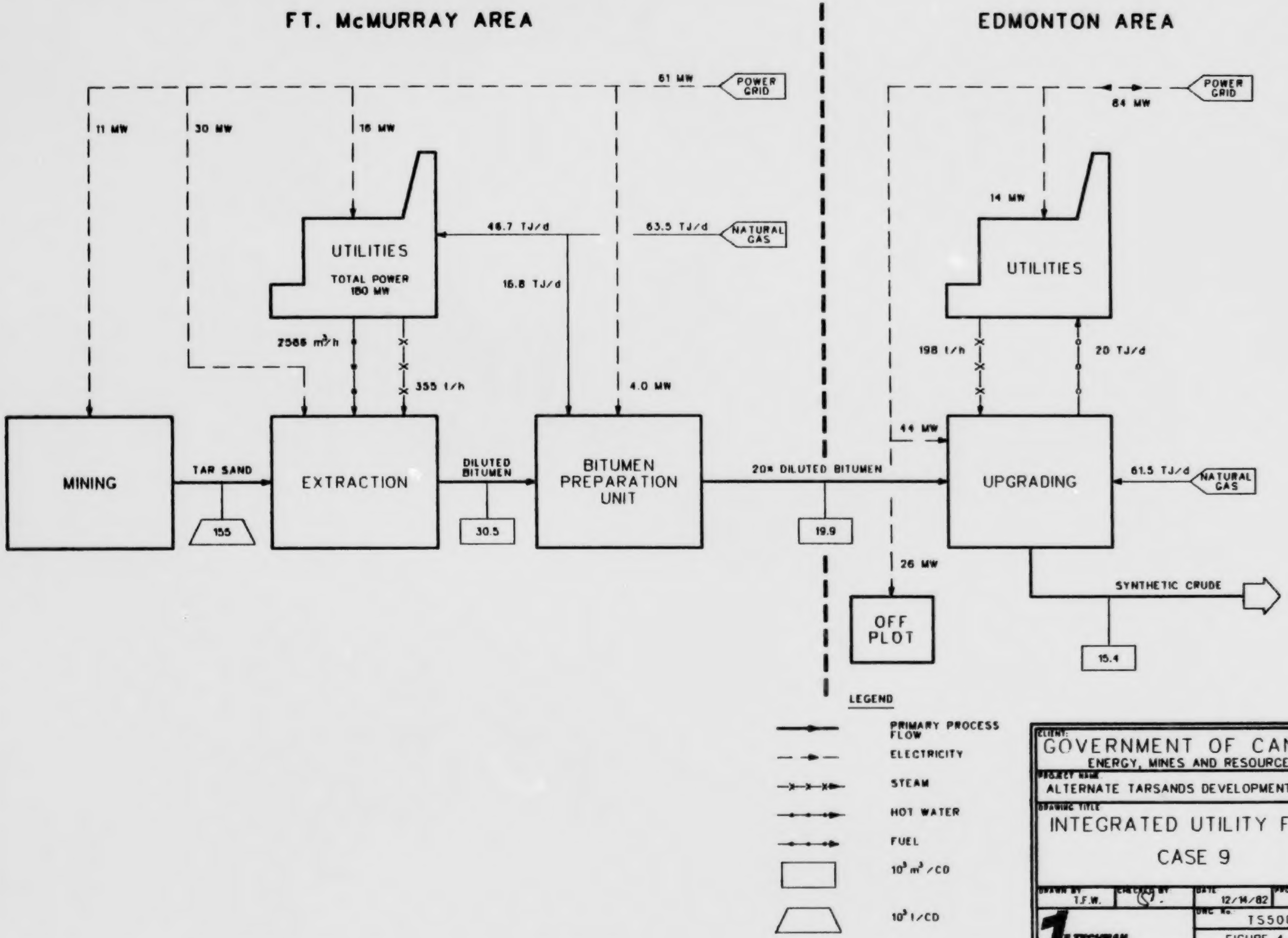
CLIENT: GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME: ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE: PROCESS FLOW SUMMARY
CASE 9

DRAWN BY: T.F.W
CHECKED BY:
DATE: 12/14/82
PROJECT No.: TM-500
DWG. No.: TS5008030

FIGURE 4.3-17


FT. McMURRAY AREA
EDMONTON AREA
POWER GRID
61 MW
11 MW
30 MW
16 MW
UTILITIES
TOTAL POWER 180 MW
46.7 TJ/d
63.5 TJ/d
NATURAL GAS
16.8 TJ/d
2588 m³/h
355 t/h
4.0 MW
MINING
TAR SAND
155
EXTRACTION
DILUTED BITUMEN
30.5
BITUMEN PREPARATION UNIT
20% DILUTED BITUMEN
19.9
POWER GRID
84 MW
14 MW
UTILITIES
198 t/h
20 TJ/d
44 MW
UPGRADING
61.5 TJ/d
NATURAL GAS
26 MW
OFF PLOT
SYNTHETIC CRUDE
15.4
LEGEND
PRIMARY PROCESS FLOW
ELECTRICITY
STEAM
HOT WATER
FUEL
10³ m³/CD
10³ t/CD

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
INTEGRATED UTILITY FLOW
CASE 9

DRAWN BY	CHECKED BY	DATE	PROJECT No.:
T.F.W.		12/14/82	TM500

DWG No. TS5008019

FIGURE 4.3-18

4.3.9.2 Extraction

The extraction process and mechanical equipment requirements are the same as that required in Case 2 (Section 4.3.2.2).

The same comments in reference to utilities steam supply as in Cases 6 and 8, apply for Case 9, as no waste heat is available from the remotely located upgrader.

4.3.9.3 Upgrading

The Case 9 upgrading scenario basically tests the previously presumed advantages of the build-up upgrader of Case 6.

In this case, the entire upgrader of H-Oil followed by Delayed Coking for 15.9k m^3/CD (100,000 BPCD) of bitumen is assumed built in one step. As in Case 6, the upgrader is assumed remote from the mine site, that is, in the Edmonton area. This necessitates the need for a Bitumen Preparation Unit at the mine site and the use of the AOSPL facilities to transport 20 percent diluted bitumen to the Edmonton area. Both the transportation of diluted bitumen to the Edmonton area and the return of recovered diluent back to the mine site is achieved on a tariff basis.

In building the entire upgrader at one time, the advantage of delaying some capital costs is lost, but some advantage is gained through a reduction in total number of process units. For example, two secondary upgrading trains only are required for the entire upgrading complex, and only one Delayed Coking Unit is needed to accommodate both H-Oil trains.

Product yields, natural gas imports and the disposal of coke and sulphur at no net value are identical to those derived for Case 6 - Final Phase.

4.3.9.4 Utilities

This case is identical to the final phase of Case 6.

4.3.9.5 General and Off-Plot Area

The general and off-plot requirements for Case 9 are as described for Case 1.

4.4 Analysis of Selected Schemes

4.4.1 Introduction

The Kepner-Tregoe (K-T) method was used in the analysis of the nine selected cases to identify the most attractive alternatives from those considered, and from the analysis, draw preliminary conclusions relative to size, technology, structure and ownership.

The steps in the K-T process can be summarized as follows:

i. make decision statement
ii. list the objectives and classify them into "Musts" and "Wants" that the decision must satisfy. "Must" objectives have to be achieved, while "Wants" are quantifiable and alternatives are measured by the degree to which they satisfy "Wants"
iii. evaluate the relative weight to be assigned to "Wants" on a scale of 1 to 10
iv. identify alternatives to be considered
v. evaluate alternatives against the "Musts" and "Wants", rejecting alternatives that don't satisfy the "Musts" and scoring the performance of remaining alternatives against the "Wants"
vi. select best alternatives

vii. evaluate adverse consequences
viii. make the final decision.

In the analysis, the Concept Development Team identified the objectives, which are summarized in Sections 4.4.2 and 4.4.3. The Concept Development Team also identified a large matrix of alternatives from which Techman Engineering Ltd. selected a limited number of cases judged to provide the best information on the relative effects of size, technology and structure on the selection objectives.

The final analysis of the cases was accomplished separately by a Techman panel and by the Concept Development Team, and found to correspond reasonably well. Remaining differences were rationalized and the final results of the analysis are presented in Section 4.4.5.

4.4.2 "Must" Statement

The Concept Development Team concluded that there were no "Musts" that would be of use in discriminating between alternative cases. However, they also concluded that there were "Musts" relative to the pricing/taxation policy, the business environment, and the approvals procedure etc., that would have to be in place before any project would proceed; regardless of its perceived technical and economic merit. This "Must" is summarized below:

Some owner operator/potential investor companies, including several members of the Alsands Consortium who had expended considerable development time and money, have lost confidence and trust in the business/project development environment and the Governments. They emphasize that the likelihood of a future potential investor/owner being prepared to spend three to four years of development time and incur expenditures that could be in excess of 100 million dollars, before knowing if the commercial terms will result in an economically viable project, is extremely low. They consider it very necessary that ground rules which will provide a framework for the commercial and fiscal terms specific to a potential project be put in place and that they have general applicability to the industry. Further, it is necessary that the commercial and fiscal terms for a specific project be agreed to very early in the development stage of the potential project. The non-commercial terms should also be clearly understood early in the development stage.

The following features need to be developed for incorporation into a business/project development environment or regime:

- the tax and royalty regime should recognize the fluctuation in petroleum prices and be compatible with a broad range of prices. Therefore, the rates should be lower when prices are low and profit margins are down, and should increase when prices are high in order to capture a portion of what could become wind-fall profits;
- the fiscal regime (tax and royalty) should be established for an extended period and be applicable to the entire mineable tarsands industry. This would provide for stability of development of the industry, reduce uncertainty on the part of, and risk to the investor;
- industry needs assurances that the fiscal rules will not change part way through the development and operating life of the project;
- the taxation/pricing/royalty regimes should not favour a particular configuration of ownership/structure/location of facilities. The selection of the best schemes should be based on technical and economic considerations exclusive of taxation/pricing/royalty regimes;
- increased efficiency of operations should be encouraged and not be eroded by undue taxation. To do so, would discourage efficiency improvement investments and discourage research and development expenditures;

- the fiscal regime should provide incentives for the development and pioneering of new technologies;

- the imposed use of technologies should be avoided;

- taxation and royalty payments should not commence until initial capital and other investment costs have been recovered from operating revenue. In other words, until payback has been achieved;

- rates of return on investment, used as the basis for establishing the fiscal regime, should adequately recognize the risk component of a mineable tarsands project;

- foreign investment should not be discouraged;

- considerations of cost/benefit/risk need to be taken into account in establishing the environmental and natural resource utilization requirements and criteria;

- the review and approval process for non-fiscal regime matters such as labour plans, regional and industrial benefits, local employment and business opportunities, community socio/economic impacts, etc. needs to be streamlined and accelerated. Approvals should be based on objectives and intents as opposed to the requirement that detailed plans be developed for review and acceptance prior to approval being granted. An environment based on greater understanding and mutual trust is required;

- the monitoring, reporting, review and approval process during the execution phase of the project (engineering, procurement, and construction) needs to be kept manageable and not deter or detract from the successful cost- and schedule-effective control and execution of the project; and

- priority market access for the product.

4.4.3 Summary of "Wants"

The Concept Development Team identified ten "Wants" within three broad categories:

- Economic;
- Technical/Operability; and
- Socio-Economic/Environmental.

The "Wants" and their assigned weights are listed below:

maximize economic performance	10
minimize financial risk	9
minimize technical risk	8
maximize operability	8
maximize expandability	4
optimize natural resource utilization	4
minimize environmental impact	4
minimize administrative complexity	4
minimize adverse socio-economic impact	2
maximize Canadian and regional benefits	2

A summary of the factors contained within the "Wants" is included in Section 4.4.4.

4.4.4 Guidelines to "Wants"

4.4.4.1 Economic Factors

The economic factors were evaluated by using capital and operating costs and a production profile as input to Techman Engineering Ltd.'s economic model which was then used to calculate the economic performance and risk factors. It should be emphasized that the absolute capital and operating cost numbers developed in Stage I are of a low accuracy, (-5 to +50 percent). In using ratios or deltas for comparison purposes, however, the impact of this low accuracy is partially mitigated and it is our opinion that the conclusions are directionally valid. All calculations and cost estimates were in 1982 constant dollars.

Financial performance was measured by the minimum required net-back to the producer at a given discount rate (maximizing economic performance is equivalent to minimizing minimum required net-back). The input to this calculation included the time distribution of capital and operating costs, the income tax treatment of capital and operating expenses, the production profile and appropriate discount rates. Since the economic model calculated the minimum required net-back, no assumption was necessarily relative to the price of oil, the Crown Royalty Tax and Petroleum Production Taxes, such as PGRT.

Financial exposure was measured by assessing two elements: the cumulative cash flow deficit and the payback period measured from the start of the project. In general, minimizing these two elements, minimizes financial risk.

Figure 4.4-1 displays the capital and operating costs for the various cases, all rationalized to a base case assumed equal to 100. In using this figure, it should be noted that the different size cases may have different design philosophies and facilities. This chart is not designed in a manner that directly displays apparent economics of scale.

Figure 4.4-2 shows the calculated payback period for each case, displayed in years.

Figure 4.4-3 shows the financial performance and exposure as measured by minimum required net-back, payback period, and minimum value of maximum cumulative cash flow. All values are rationalized to a base case equal to 100. In all calculations a DCF rate of return equal to ten percent

FIGURE 4.4-1
CAPITAL AND OPERATING COSTS

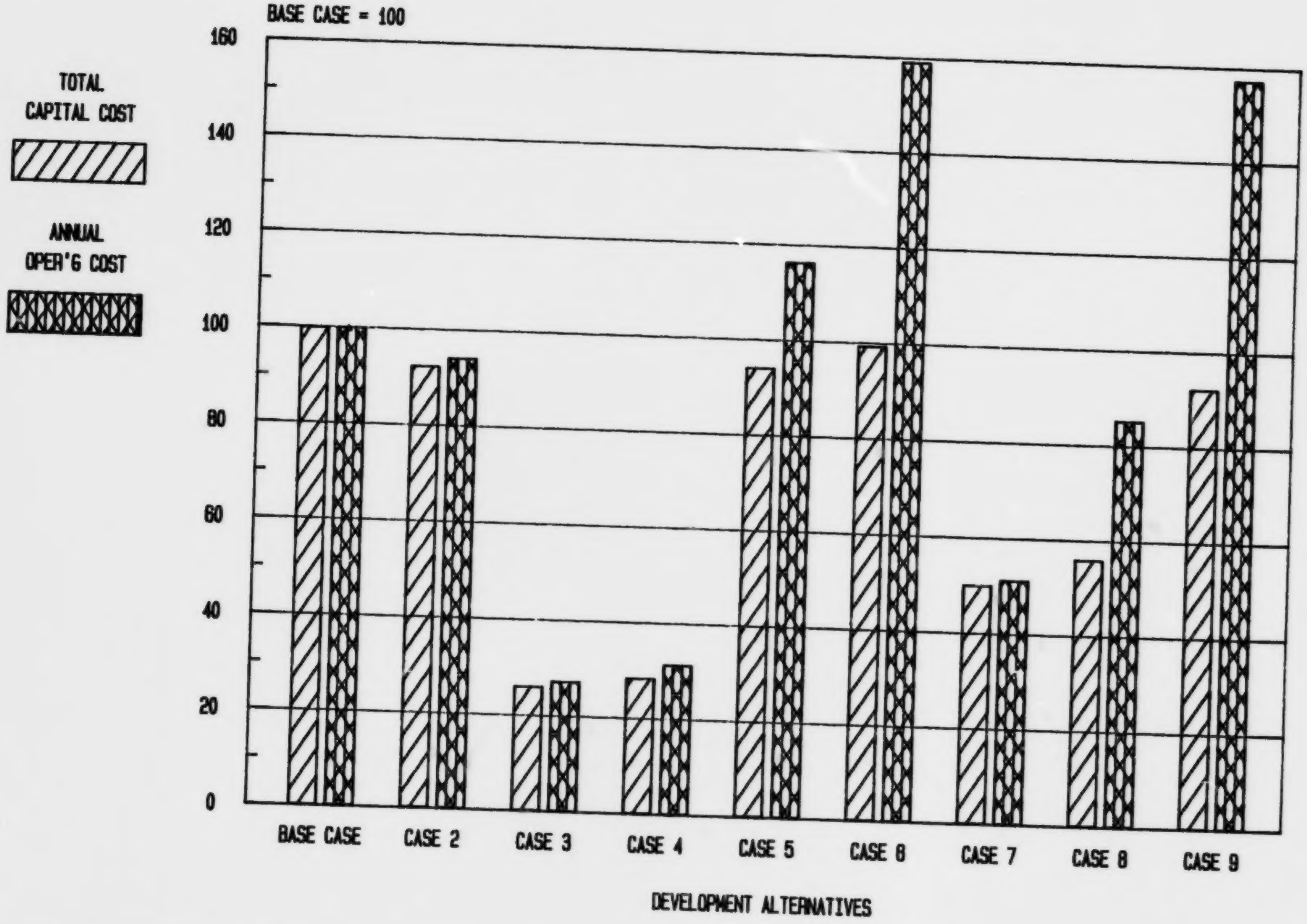


FIGURE 4.4-2
PAYBACK PERIOD

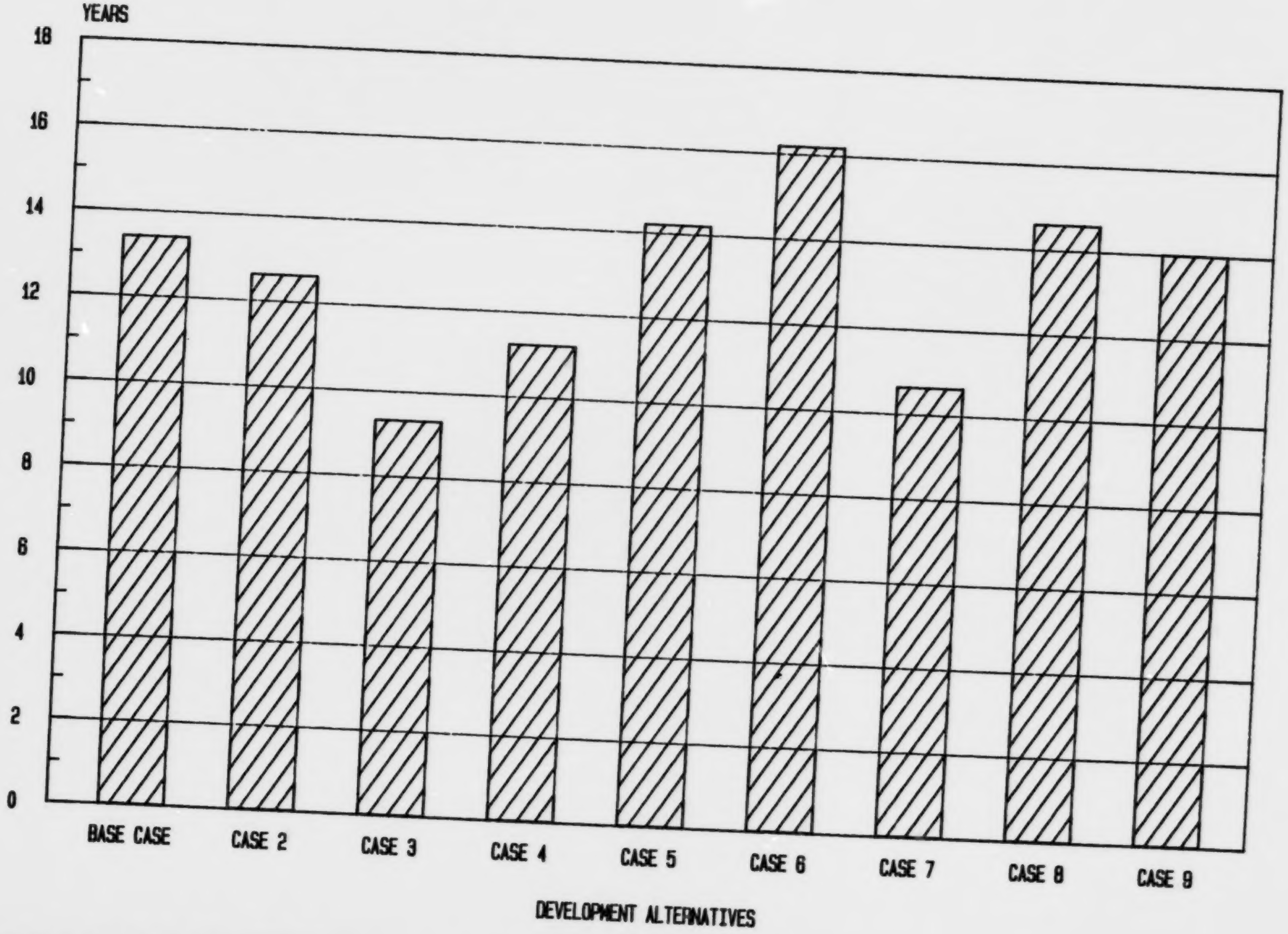
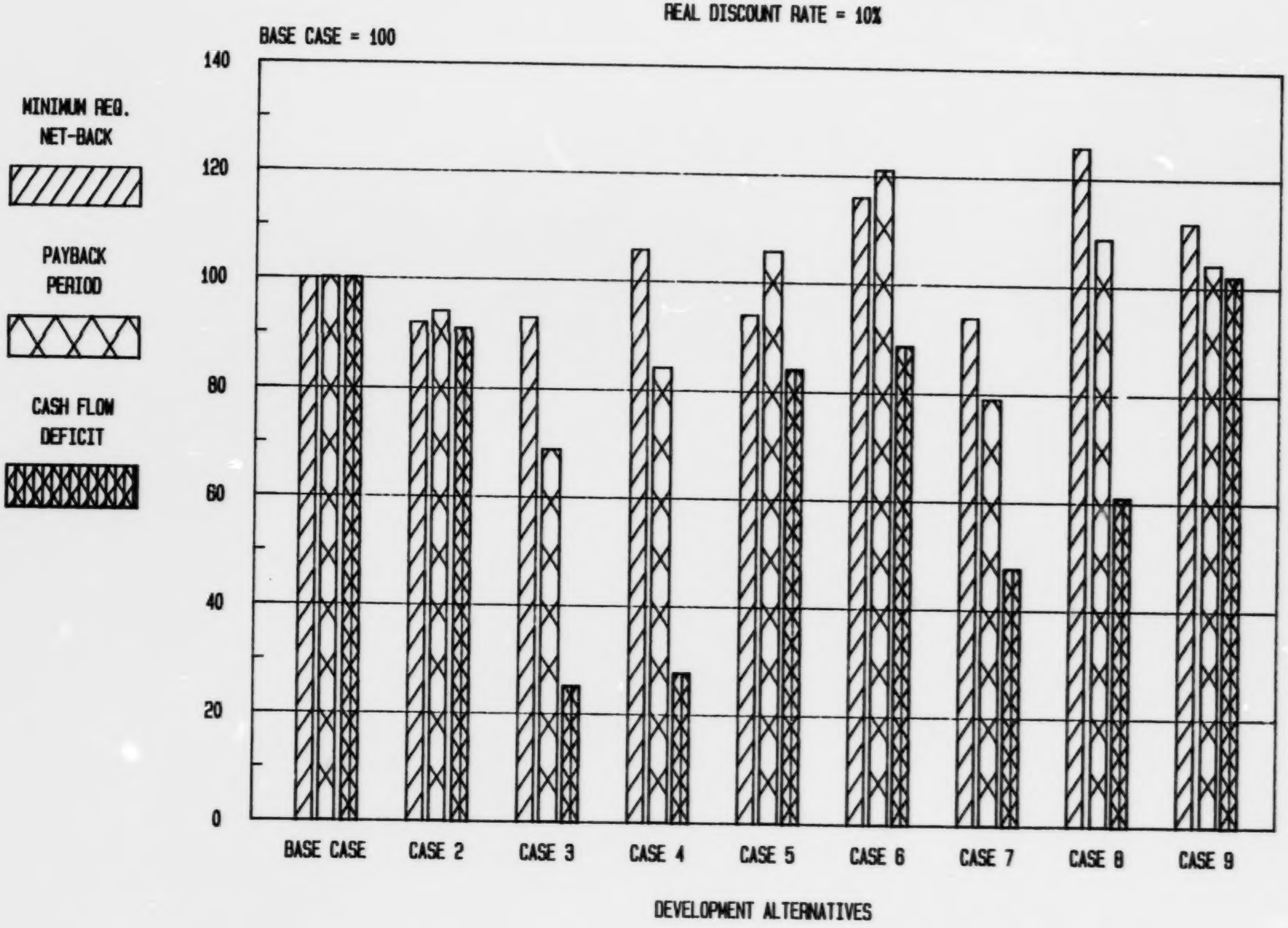


FIGURE 4.4-3
FINANCIAL PERFORMANCE AND EXPOSURE



has been used. This is for convenience only and does not represent a judgement of acceptable return to the industry relative to investment options, risk etc.

4.4.4.2 Technical/Operational Factors

Technical risk takes into account the state of development of the technology, the maturity of the process, the degree of scale-up from operating plants, experience on the specific feedstock and other factors relating to the risk of applying a particular technology in a given application.

Operability of a case considers factors such as degree of integration between processes, complexity of processes, and is another way of measuring the relative ease of achieving and maintaining operational stability of a plant.

Expandability is a measurement of ability to take advantage of potentially better future options. A plant designed and constructed in a way that makes it easily possible to expand in scale or expand using a new technology or react in the most beneficial way to changing circumstances would be judged to have high expandability in accordance with this criteria.

Administrative complexity is a measurement of the complexity arising out of the project execution plan and ownership structure. In general, a smaller project is a simpler project to build and requires few owners to share the risk.

4.4.4.3 Environmental/Socio-Economic Factors

The utilization of natural resources is a measurement of the efficiency of the plant in producing liquid fuels while consuming energy in the form of fuels, natural gas and electrical power, and recovering the bitumen from a tarsands lease in a cost-effective way.

The environmental impact of a plant addresses all noxious emissions and effluents, areas required for tailings ponds, land disturbances etc.

The socio-economic impact of a development is a measurement of the strain put on the social infrastructure. This is minimized by levelling employment peaks and valleys, both geographically and in time, and by creating employment and business opportunities for indigenous people.

The maximization of Canadian and regional benefits takes into account a projects contribution to increased business, employment and export opportunities, the development of skills, and the product's contribution to energy self-sufficiency, balance of payments, and the enhancement of the tax pool.

4.4.5 Results

The economic factors were weighted in the K-T analysis in a very mechanistic, objective manner. The operational/technical factors and the environmental/socio-economic factors were more subjective and required considerable dialogue and judgement to finalize results. A cursory sensitivity analysis indicates that the directional information presented in Section 5.0, Conclusions, is valid for a wide range of scoring of the subjective discriminators.

In general, the smaller cases appeared attractive economically, and also from the point of view of acceptable technical risk and minimum administrative complexity. The build-up cases scored well relative to operability and technical risk, utilization of resources, minimization of adverse socio-economic impacts and maximization of Canadian benefits. Remote upgraders suffered an economic penalty because of higher operating costs. Considering only non-economic factors, the build-up cases appeared most attractive; on an economic basis, the smaller case using mobile equipment mining technology appears the best.

The final result of the K-T analysis is presented on Table 4.4-1.

Table 4.4-1

Evaluation of Cases Against "Wants"

Wants	Weight	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6		Case 7		Case 8		Case 9	
		WT	S	WT	S	WT	S	WT	S	WT	S	WT	S	WT	S	WT	S	WT	S
Minimum Technical Risk	8	10	80	9	72	9	72	9	72	8	64	9	72	9	72	7	56	7	56
Maximum Operability	8	9	72	9	72	7	56	5	40	8	64	10	80	7	56	9	72	9	72
Maximum Expandability	4	5	20	5	20	8	32	8	32	10	40	10	40	6	24	7	28	7	28
Optimum Natural Resource Utilization	4	5	20	6	24	6	24	4	16	10	40	8	32	6	24	8	32	8	32
Minimum Environmental Impact	4	5	20	6	24	7	28	6	24	9	36	9	36	6	24	10	40	9	36
Minimum Administration	4	5	20	4	16	10	40	9	36	7	28	6	24	7	28	6	24	4	16
Minimum Adverse Socio-Economic Impact	2	6	12	6	12	9	18	9	18	9	18	10	20	8	16	8	16	7	14
Maximum Canadian Benefits	2	7	14	7	14	6	12	6	12	10	20	10	20	7	14	7	14	8	16
Sub-Total - Non Financial			258		254		282		250		310		324		258		282		270
Sub-Total - Financial			106		145		190		122		135		66		162		55		76
Total			364		399		472		372		445		390		420		337		346

5.0 CONCLUSIONS

5.1 Introduction

As noted in previous sections, the selection of cases in Stage I was designed to separately test the elements of primary interest in the study, namely size, technology, ownership and structure. The conclusions, which are necessarily preliminary due to the quality and quantity of data generated in Stage I, provide directions for the more detailed evaluation to be undertaken in Stage II. Stage I then, does not directly allow us to eliminate cases, nor does it facilitate a direct selection of a lesser number of alternatives from the slate of alternatives examined in Stage I. Instead, it provides a base of information and direction for an intelligent selection of cases to be examined during Stage II. The conclusions to be drawn from Stage I work are related to directional information, and tell us where to look for the optimal development scheme as regards to size, technology, ownership and structure.

5.2 Size

A smaller scale of development appears attractive, although the Stage I data doesn't allow us to specifically identify the optimum size, nor definitively examine and quantify the attractiveness of small developments. The small case examined in Stage 1 was arbitrarily selected at 4k m^3/CD (25,000 BPCD) of bitumen feed to the primary upgrader. Stage 2 will more closely select the optimum small size, which may be somewhere between 2.4k m^3/CD (15,000 BPCD) and 5.6k m^3/CD (35,000 BPCD) fresh bitumen feed. The optimum sizes and technology will be assessed against the risk and reward criteria established in Stage I. The primary reasons for the attractiveness of the small case is the lower financial risk, (shorter payback period and lower initial investment) and the relatively better economic performance as indicated by the lower required net-back. A smaller scale plant is also perceived to have an acceptable technical risk.

A build-up case, where the operator makes an initial investment in a smaller plant, designed to subsequently expand to a large plant partially built by cash flow from the initial small plant, also appears attractive. The Stage I data doesn't allow us to draw firm conclusions regarding the best initial size, nor the build-up increments. The apparent advantages of this case are the ability to expand the plant out of cash flow generated by an initial smaller operation and the ability to take advantage of potential future technological development.

5.3 Technology

Techman Engineering Ltd. has developed a mining scheme, based on a modular concept, using mobile equipment in an innovative way that minimizes transport distances. It is particularily applicable to smaller sizes and is readily expandable. Although this scheme needs to be developed and examined in greater detail, it preliminarily appears economically attractive. The scheme is outlined in Appendix C.

During Stage I, we have identified potential technology enhancements in mining, extraction and upgrading, and have qualitatively outlined the driving force for development and incorporation of these enhancements. Additional work to quantify the driving forces where possible, and where data is available, is required and is planned for Stage II. A more comprehensive listing of identified technology enhancements is included in the minutes of the Concept Development Team meetings (Appendix A, pages 195-198).

5.4 Ownership and Structure

New mining and extraction facilities supplying bitumen to Suncor Inc., Syncrude Canada Ltd. or to certain existing Edmonton refineries, appear to have good potential. These schemes each require a special business arrangement, and capital and operating cost data that can only be developed with the participation and assistance of the owners and, therefore, have not been examined in any detail in Stage I, nor is it planned to evaluate these schemes in detail in Stage II. The pertinent cost and operating data for separate mining/extraction operations will be developed for examination of remote upgraders.

6.0 RECOMMENDATIONS

6.1 Introduction

Using the directional information and the data developed during Stage I, it is our recommendation that Stage II proceed immediately to confirm the preliminary results. Specifically, cases should be designed, optimized and examined to:

- confirm the desireability of smaller sized plants and determine the optimum small size;
- further examine the build-up case, to confirm its attractiveness, determine best initial size and optimal build-up increments, and select best initial technologies;
- further develop the modular mobile equipment mining scheme;
- identify potential technology enhancements and, as far as possible, quantify the driving force for development and incorporation; and
- examine the remote upgrading scenario by:
  - developing costs for stand alone remote mining/extraction facilities
  - developing costs for the "grass-roots" remote upgrader
  - gathering preliminary data for the associated upgraders to be located at existing tarsands plants or refineries.

6.2 Work Statement for Stage II

The specific tasks proposed and recommended for Stage II are listed in the following work statement.

Task 1

List all schemes selected for evaluation. This list will include all schemes selected by Task 4 of Stage I of the study, augmented or adjusted by any later intelligence during the completion of Stage I.

Divide schemes according to type, as follows:

- integrated (interconnected from a physical and energy viewpoint);
- distributed (non-integrated, local upgrader);
- remote upgrader (upgrader located some distance away);
- build-up (plant goes into operation at small scale and subsequently expands); and
- piggybacked (new facility synergistically connected to an existing tarsands plant or refinery).

Task 2

Determine appropriate service factors for various component processes and make provisional process train assumptions to facilitate preliminary sizing of the extraction and upgrading units. In performing this task, the following factors should be taken into account:

- equipment redundancy;
- process reliability;
- maintenance requirements;
- storage of intermediate products; and
- unit turn-down.

Task 3

Review available geological data for mineable tarsands area and develop representative geological profiles upon which to base mining plans. The geological column should be representative and provide for normally encountered problems. Items to be considered include the following:

- overburden depth;
- orebody depth;
- bitumen saturated sand (grade and thickness);
- lean tar sand and clay (grade and thickness);
- inclusions (indurated siltstone);
- orebody variability, both areally and with depth; and
- aquifers.

Determine the applicability of the column and develop additional data, if required (the selected scheme or schemes are to have substantial general applicability, and be specifically applicable to at least one lease).

Task 4

Develop design of selected mining schemes at each size, completely scoping and sizing equipment, to develop the following data for each scheme:

- yearly cost schedule (contract, capital and operating);
- service factors;
- energy requirements, source and type;
- illustrate the operability of the mining schemes with mining schematic drawings (cross sections and plans) and material balance schedules;
- evaluate impact of selective mining on mining dilutions, feed grade extraction recovery, tailings disposal and extraction costs; and
- include tailings disposal as an integral part of mine planning.

Task 5

Develop size limitations and optimum sizes, if such exist and are different from selected cases, for various mining schemes, and develop concomitant cost data. The output of this task will be an optimized mining technology over all size ranges and the cost function corresponding to size and technology, considering both operating and capital costs.

Task 6

List proprietary extraction technologies identified for evaluation and contact licensors/developers to obtain current available data. Data required will include the following:

- state of development of the technology and schedule for commercial demonstration if unproven;
- ability to process varying feed qualities;
- required feed conditioning;
- energy and utilities requirements;
- recovery efficiencies with different feed grades;
- quality of product;
- nature and quantity of tailings;
- capital and operating cost data, basis and source of cost data;
- size limitations and basis for sizing parameters; and
- anticipated or demonstrated service factor.

Task 7

Develop preliminary process scheme for extraction units at each size selected, taking into account service factors and process train assumptions. The data developed should include the following:

- energy and material balances;
- product quality;
- quantity and nature of tailings streams;
- requirements for chemicals and solvents;
- capital and operating costs; and
- size exponent of capital cost at each size.

Task 8

Identify extraction processes whose state of development precludes their consideration in the short-run, but whose potential advantages are attractive in the long-run. Quantify the driving force for development and the probable development schedule. Consideration should be given to the following:

- potential economic advantages
  - lower capital costs
  - lower operating costs

  - shorter project schedule
  - greater bitumen yields

- potential operability improvements
  - better service factor
  - simpler operation
  - better performance on low-grade ores

- potential mitigation of adverse environmental and socio-economic impacts
  - better resource utilization
  - better quality tailings
  - reduction in tailings pond area

Task 9

List proprietary upgrading technologies identified for evaluation and contact licensors to obtain current, available data. Data required will incude the following:

- state of development of the technology (pilot scale, demonstration scale, commercially proven);
- experience with extracted Athabasca bitumen;
- yield data as demonstrated or predicted;
- product quality data;
- energy balances and utility requirements;
- capital and operating costs data and basis and sources of cost data;
- size limitations and basis for sizing parameters;
- suggested overall processing scheme; and
- service factor.

The technologies considered should cover both primary and secondary upgrading and ancillary units such as hydrogen production units, sulphur recovery, etc.

In most cases, the data will be available as sales data from licensors. In some cases, a non-disclosure agreement will be required to access required information.

Task 10

Develop preliminary process scheme for upgrading units at each size selected, including both primary and secondary upgraders and ancillary units, and taking into account the service factors of various units and process train assumptions. The following data should be developed:

- energy and material balances;
- product qualities;
- capital and operating costs; and
- size exponent of capital cost at each size.

Task 11

For each size and type (i.e., location) of primary upgrader, select the optimal upgrading scheme from those developed in Task 4 (Stage I), if there is an obvious basis for the choice. For example, a choice between fluid, flexi, and delayed coking could probably be made at this time. If the trade-offs are between capital and operating costs or if there are significant differences in energy balances which could affect integration with the extraction unit, carry competing technologies into the optimization and evaluation stage.

Task 12

Identify upgrading processes whose state of development precludes their consideration for the short-run, but whose potential advantages are attractive in the long-run. Quantify the driving force for development and the probable development schedule. Consideration should be given to the following:

- potential economic advantages
  - lower capital costs
  - lower operating costs
  - shorter project schedule
  - greater product yield

- potential operability improvements
  - better service factor
  - simpler operation
  - requires fewer ancillary units
  - operationally flexible
  - low maintenance requirements

- potential mitigation of adverse environmental and socio-economic impacts
  - fewer by-products
  - fewer and less objectionable emissions
  - better resource utilization
  - less intense utilization of social resources
  - creation of employment and business opportunities

Task 13

Develop design of utilities and offplot facilities for the various types and sizes of development scenarios and develop cost data for all of the following:

- tankage;
- maintenance facilities, mining and process area;
- service buildings;
- water and waste treatment facilities;
- site improvements - grading, roads, fencing;
- steam and power generation; and
- product and natural gas pipelines.

Task 14

Develop preliminary plant operating cost data for the various types and sizes of plants selected. Consider the following cost elements:

- operating labour;
- maintenance labour;
- catalysts and chemicals;
- parts and supplies; and
- fuel and power.

Task 15

Develop total schemes for the various sizes and types of plants, including utilities and energy balances, matching of service factor, etc. Review the provisionally selected sizes, considering the size/cost function of the mining designs and the size exponent of cost for extraction and upgrading, to determine if the sizes selected are sub-optimum. If selected sizes are not optimal, select optimal sizes, guided by the cost functions.

Review work to date by Project Advisory Committee.

Task 16

Develop process design for all selected overall schemes taking into account any new size considerations arising out of Task 15 and process sub-optimization developed in Task 11. Data available as output from this task, should include, for each size and type:

- overall process flow diagram;
- energy and material balances;
- project development schedule;
- product qualities;
- utilities requirements and sources;
- probable project execution plan, to define infrastructure requirements and impacts;
- operating and capital costs and revenues;

- cash flow profile;
- environmental impact;
- socio-economic impacts;
- resource utilization;
- Canadian and regional industrial benefits; and
- significant non-economic and non-technical differences from a typical mega-project, including:
  - quality of facilities (redundancy, sparing, design life, service factor)
  - state of development of technology
  - disposal of by-products
  - employee related infrastructure

Task 17

Using the cost data for each scheme, develop the comparative criteria for economic performance, financeability and financial risk, using Techman Engineering Ltd.'s economic model. Run sensitivity analyses parametrically and put estimates on a probabilistic basis using risk analysis techniques.

Task 18

Using all data developed in Task 16 and 17, test each remaining case against the viability criteria established during Task 4 of Stage I:

- maximize financial performance;
- minimize financial exposure;
- maximize operability;
- minimize technical risk;
- maximize expandability;
- minimize adverse environmental impact;
- maximize resource utilization;
- minimize administrative complexity;
- maximize Canadian and regional benefits; and
- minimize adverse socio-economic impacts.

Rank the cases within each type i.e., by permutations of size and technology.

Task 19

Select the best scheme(s), taking into account the following:

- development timetable;
- ranking of schemes;
- degree of development of selected technologies; and
- driving force for development of "soft" technologies.

Task 20

Review results with Project Advisory Committee, rationalizing results versus viability criteria, reviewing weights within the decision algorithm and recycling as required to arrive at the agreed selection of schemes.

Task 21

Complete documentation of the selected scheme(s) including all relevant data, some of which must be developed and some of which was previously developed in the Concept Development Team meetings, such as:

- required business environment for the advancement of the selected project, including all matters of policy and economics, stability of the business environment, etc.;

- required technology developments to support selected schemes and driving force for all identified potential enhancements; and

- areas where additional study or development work is required - possibly demonstration scale operations - beyond the scope of this study.

Task 22

Prepare final report, including the following:

- documentation of selected scheme(s) including business environment;
- analysis of cases;
- outline of all cases examined;
- suggested future enhancements and required technology advancements including driving force for all identified potential enhancements; and;
- required additional study work or pilot work.

Task 23

Present results to audiences selected by the Government. This task includes preparation of required presentation material.

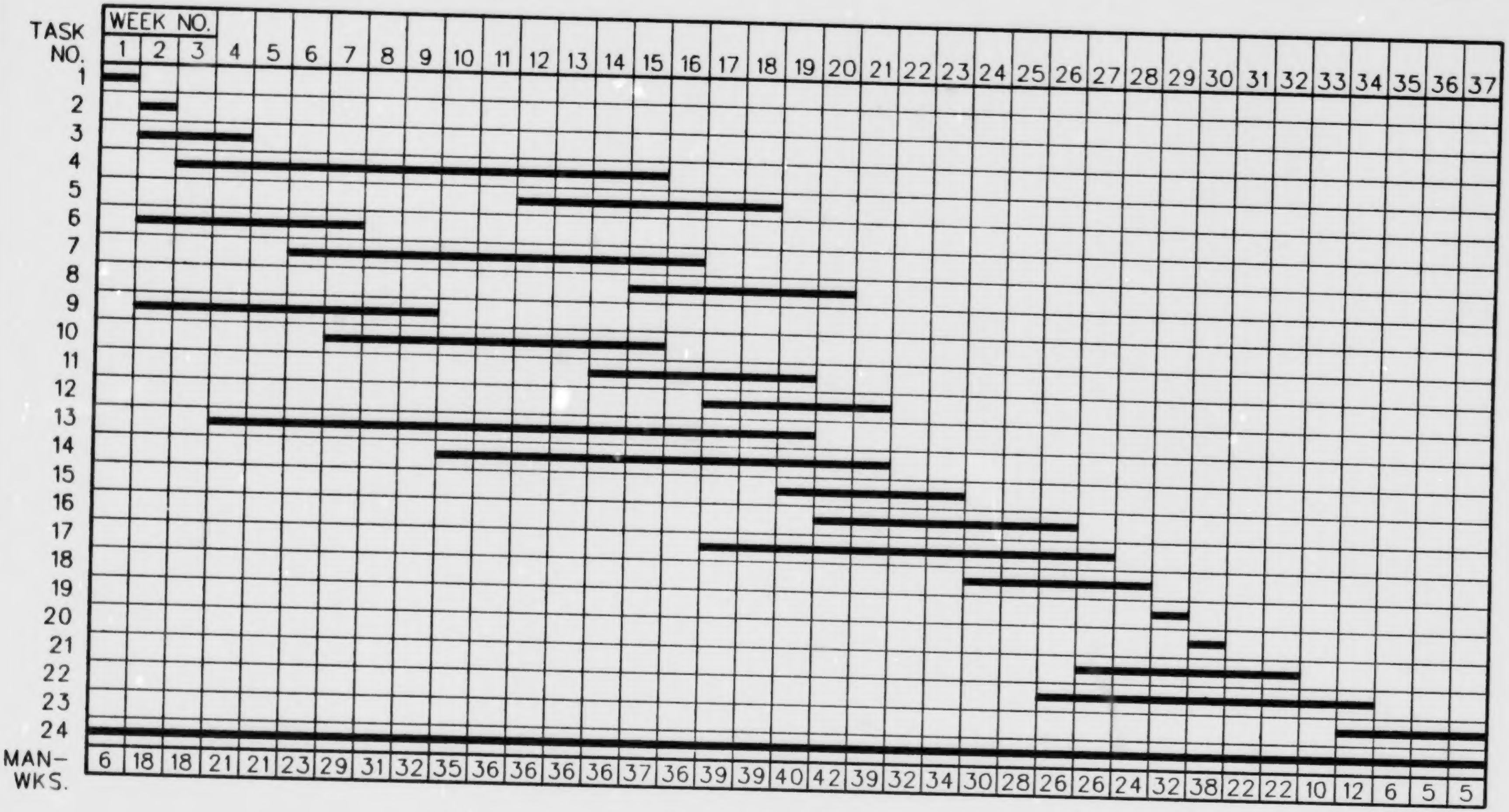
Task 24

This task is to cover project management of the study, including:

- project management;
- project services;
- cost and schedule control;
- project accounting;
- client liaison; and
- periodic progress reporting.

6.3 Stage II Schedule

The schedule proposed to accomplish the work recommended for Stage II is shown in Figure 6.3-1.



CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
TASK SCHEDULE
STAGE II

DRAWN BY T.F.W.
CHECKED BY
DATE 12/14/82
PROJECT No.: TM500
DWG No.: TS5008027
FIGURE 6.3-1

References

McRory, R.E. 1982. Energy Heritage: Oil Sands and Heavy Oils of Alberta. Prepared for Alberta Energy and Natural Resources, Edmonton, Alberta.

Glossary of Terms

API Degrees:
Density or mass (weight per unit volume) of crude oil or bitumen as measured by a system recommended by the American Petroleum Institute.

Barrels Per Calendar Day (BPCD):
Total average production based on a 365 day period.

Barrels Per Stream Day (BPSD):
Total average production based on barrels of bitumen per operable day.

Bitumen:
A naturally-occurring viscous mixture of hydrocarbons that may contain sulphur compounds and that, in its naturally-occurring state, is not recoverable at a commercial rate through a well.

Bucketwheel Excavator:
A mining machine which utilizes toothed buckets mounted on the rim of a revolving wheel to scoop up tarsand and deposit it on a conveyor system.

Bucketwheel Reclaimer:
Similar to a bucketwheel excavator, used to recover mined tarsand from windrows and move it to a conveyor system.

Coke:
The solid, black hydrocarbon left as a residue after the volatile hydrocarbons have been removed from bitumen by distillation.

Cokers:
The vessels in which bitumen is "cracked" into its fractions.

Cracking:
The process of breaking down the larger, heavier and more complex hydrocarbon molecules into simpler, lighter molecules. Separating crude oil or bitumen into fractions.

Delayed Coking:
Patented process for converting fluid coke into a usable fuel gas - very similar to flexi-coking.

Deposit:
An accumulation of oil capable of being produced commercially.

Glossary of Terms
(Cont'd)

Diluent:
A liquid used to dilute bitumen to the point where it will flow.

Distillate:
Liquid hydrocarbons produced with natural gas which are separated from the gas by cooling and various other means.

Dragline:
A mining machine which drops a heavy toothed bucket on a cable from the end of a boom into the tarsand, then drags the bucket through the deposit, scooping up the sand. Once full, the bucket is raised and emptied onto a windrow.

Enhanced Recovery:
Recovery of oil by the implementation of an artificially improved depletion process.

Extraction:
The process by which the bitumen is separated from the sand, water and other impurities.

Fines:
Minute particles of solids such as clay or sand.

Flexi-coking:
A patented process for converting fluid coke into a usable fuel gas.

Fluid Coke:
Coke in the form of small granules which can be aerated, blown through a pipe, and will flow like a liquid.

Fraction:
A separate, identifiable part of crude oil; the product of refining or distillation. Crude oil is divided into hundreds of fractions - gases, fuels, oils, asphalts and coke.

Fractionation:
The process by which bitumen is separated into its fractions.

Froth:
A mixture of air, water and bitumen which rises to the surface of the primary separation vessel.

Glossary of Terms
(Cont'd)

Hot Water Flotation:
The process by which oil sand is mixed with hot water, then aerated. The heavier-than-water bitumen clings to air bubbles which carry it to the surface.

Hydrocarbons:
Organic chemical compounds of hydrogen and carbon atoms which form the basis of all petroleum products.

Hydrocracking:
A refining process for reducing heavy hydrocarbons into lighter fractions, using hydrogen and a catalyst.

Hydrotreating:
Mild hydrocracking.

In situ:
In-place.

Middlings:
The mixture of water, clay, sand and bitumen that remains between the bitumen froth at the surface and the sand at the bottom of a primary separation vessel.

Oil Sand:
Sand and other rock material which contain crude bitumen. Often referred to as tarsand.

Overburden:
The layer of sand, gravel and shale which overlies the tarsands.

Petroleum:
In a general sense, all hydrocarbons; usually, crude oil.

Pilot Plant:
A small model plant for testing processes under actual production conditions.

Primary Separation Vessel:
The vessel in which the first separation of bitumen from sand takes place.

Glossary of Terms
(Cont'd)

Reclamation:
Returning disturbed land to a productive state.

Secondary Recovery:
The use of waterflood, gas injection or other methods to recover additional amounts of oil.

Surface Mineable Tarsands:
Any deposit of tarsand which has an approximate strip ratio of 1:1, or less and an overburden thickness of not greater than 90 m that can be mined by current surface mining techniques.

Synthetic Crude Oil:
Crude oil produced by upgrading bitumen.

Tailings:
Waste products from the mining, extraction and upgrading processes.

Tailings Pond:
An enclosure to contain tailings.

Tarsand:
Sand and other rock material which contains crude bitumen. Often referred to as oil sand.

Upgrading:
The conversion of bitumen into synthetic crude oil.

Viscosity:
The ability of a liquid to flow. The lower the viscosity, the more easily the liquid will flow.

Windrow:
An elongated pile of tarsand material scraped to the side of a road.

Volume

2

TARSANDS DEVELOPMENT STUDY

STAGE I

VOLUME II

APPENDIX A MINUTES OF THE CONCEPT DEVELOPMENT TEAM MEETINGS (OCTOBER, 1982)
APPENDIX B MINUTES OF THE CONCEPT DEVELOPMENT TEAM MEETINGS (DECEMBER, 1982)

SUBMITTED BY

TECHMAN ENGINEERING LTD.

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources, Canada

DSS File Number: 15SQ. 23440-2-9131
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CANMET Scientific Authority: Mr. V. Srajer

244 pp
2 figs

Acknowledgements

Techman Engineering Ltd. wishes to gratefully acknowledge the participation of the following individuals on the Concept Development Team:

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Dr. E. Yildirim
Manager Oil Sands Technology
Alternate Fuels
Cities Service Company

Their free and full participation contributed in a major way to the success of Stage I of the study: the assumptions, conclusions and recommendations documented herein, however, are the sole responsibility of Techman Engineering Ltd. and are not represented to be a reflection of the opinions of individual members of the Concept Development Team, nor of their companies or agencies.

In describing the cases examined in this study, reference is made to certain proprietary processes in extraction and upgrading and to specific equipment items in mining. These references are illustrative and do not represent an endorsement of particular equipment items or manufacturers, nor do they reflect an opinion on the relative suitability of processes in certain applications since Stage I did not include process optimization or any detailed comparative evaluation of competing processes. Processes were selected primarily on the basis of proven technology.

APPENDIX A

MINUTES OF
THE CONCEPT DEVELOPMENT TEAM
MEETINGS

OCTOBER, 1982

MINUTES OF THE MEETINGS OF THE CONCEPT DEVELOPMENT TEAM

The Concept Development Team convened at 10:30 A.M., on Thursday, October 7, 1982. All of the team members, which are listed below, were present.

Attendees:

Dr. D.W. Devenny
Gulf Canada Resources Inc.

Mr. F. Callaway
Home Oil Company Limited

Mr. G.K. Lewis-Steer
Petro-Canada Exploration Inc.

Dr. J.E. Filby
OSTR Group
Petro-Canada Ltd.

Mr. F.M. Ratushny
Shell Canada Resources Limited

Mr. R.M. Wrubleski (alternate)
Shell Canada Resources Limited

Mr. A.W. Hyndman
Syncrude Canada Ltd.

Mr. K.I. Clarke
Bechtel Canada Limited

Mr. D.E. Rose
Dereng Enterprises Ltd.

Mr. J. Guthrie
James Guthrie Consultants Ltd.

Mr. T.J. McCann
RTM Engineering Ltd.

Techman Personnel:

Mr. A.W. Wirth
Mr. D.M. McClement
Mr. C.B. Abbott
Mr. A.G. Blair
Ms. M. Gee (part-time)
Mr. D.S. Kim
Mr. J.W.R. Porteous
Mrs. J. Schwalm (part-time)
Mr. P.M.T. White

...2

1. INTRODUCTORY COMMENTS

A.W. Wirth, Vice President & Project Director, Techman Engineering Ltd., and Concept Development Team Leader, welcomed the members to the Techman facilities and expressed his personal appreciation for the outstanding response from Tarsands Project Owner/Potential Owner Companies, and the fact that the team members individually and collectively brought to the deliberations a very impressive amount of tarsands experience and knowledge.

The individual team members introduced themselves, also advising as to their company affiliation and their position within their company.

Art Wirth advised the group that during the deliberations of the Concept Development Team his role would be one of Leader/Chairman/Facilitator, as deemed appropriate for various aspects of the deliberations. He emphasized the fact that the success of the Concept Development Team deliberations was very much a function of the degree of and quality of participation by the members. Wirth advised the group that:

- Techman Engineering Ltd. had been commissioned by the Federal Government to manage a tarsands study intended to examine alternates of scale, technology, ownership and structure, etc. The underlying purpose being that of finding a way to make a "Mineable Tarsands Project" proceed.
- The deliberations of the Concept Development Team will be recorded and Minutes prepared.
- The study will encompass only Surface Mineable Tarsands Projects.
- The Concept Development Team is scheduled to meet on October 7, 8, 12, 13, 14, and 15th, then break for a week and reconvening on Monday, October 25th and continuing on until its main tasks are completed.

The group concluded that the proposed discussion outline, attached to Wirth's letter of September 29, 1982, to the team members was acceptable. Wirth advised that Topic 2 would follow Topic 4 and that Topic 9 would be deferred to Tuesday, October 12th.

PROPOSED DISCUSSION OUTLINE

TOPIC	DISCUSSION LEADER
1. Introductory Comments	A.W. Wirth
2. Overview of the Scope of and the Proposed Approach to the Study (Stages 1 and 2)	D.M. McClement
3. Draft General Study Objectives (Stages 1 and 2)	A.W. Wirth

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4.	Proposed Specific Stage 1 Objectives and Tasks	D.M. McClement
5.	Stage 1 Product - Report and Seminar Material	D.M. McClement
6.	Proposed Role of the Concept Development Team	A.W. Wirth
7.	Review/Modify/Accept Study Objectives (General and Specific)	et al
8.	Review/Modify/Accept Overall Study Approach and Methodology (Tasks)	et al
9.	Review/Modify/Accept Results of Task II Work done by Techman	J.W.R. Porteous
10.	Presentations and Discussions on the Current State of the "Art" and Potential Applications in the following areas:	
	a) Mining	C.J. Abbott
	b) Extraction	J.W.R. Porteous/ D.E. Rose
	c) Upgrading	T.J. McCann/ D.M. McClement
	i) Delayed Coking, Fluid Coking, Flexi Coking, Visbreaking, etc.	
	ii) LC-Fining, HRI Hydrocracking, etc.	
	iii) Hydrotreating or Mild Hydrocracking	
	iv) Coke Disposition; i.e., Fuel, Hydrogen Production, Gasification, Liquefaction, etc.	
	d) Utilities	D.S. Kim
	e) Pipelining	T.J. McCann
11.	General Discussion on Technical/Operational/ Project Development/Project Approval Problems, Considerations and Constraints that should be taken into account in our Task 3 and 4 deliberations.	et al
12.	Review/Modify/Accept Framework and Approach for Addressing the Concept Development Team Deliberations relative to Tasks 3 and 4.	et al

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13. Task 3 - Develop "Musts" and "Wants" using Kepner-Tregoe or some other suitable format and approach. et al

14. Task 4 - Identify Alternate Schemes to be considered. et al

15. To the extent possible, test the Options against the "Musts" and "Wants"/Discard Options/ Identify Additional Options. et al

16. Develop Plans for Next Session; i.e., Purpose, Time, etc. at al

Concept Development Team representation from Home, Gulf, Shell, Petro-Canada and Syncrude had earlier in the morning, met with Messrs. Wirth and McClement. Al Hyndman requested that the results of that session be summarized for the benefit of the total group. Wirth summarized as follows:

- All five Owner Operator/Potential Owner Operator Companies feel very strongly that the study should not just be a technical exercise but should also consider and address Commercial and Fiscal Considerations. In particular, they consider it very necessary and important that the Ground Rules that will apply to the Commercial and Fiscal Terms be put in place very early in the development of a potential project and have general applicability to the industry. They emphasized that the likelihood of a future potential owner(s) being prepared to spend 3 to 4 years of development time and incur expenditures that could be in excess of 100 million dollars, before knowing if the commerical terms will result in an economically viable project, is extremely low.

- Each of the companies participating in the study are free to use any of the information, ideas, or concepts developed by the study, at any time in order to further the development of tarsands. Each company, however, is expected to treat such information as being commercially confidential until the Stage I report is made public, which is expected to occur no later than April 1, 1983.

- Each of the company representatives will have an opportunity to review and comment on the Stage I Report. Where total agreement cannot be reached, the disagreements will be documented and so recorded in the report.

- Each of the Concept Development Team members including Owner/ Operator/Potential Owner Operator company representatives will receive a copy of the Final Stage I Report.

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- Suncor had also been invited to participate in the study and have representation on the Concept Development Team but had seen fit to decline.

- In selecting Owner/Operating Companies for participating in the study, the following criteria were applied:

  - Owners/Operators of a mineable tarsand facility.

  - Lease Holders

  - Have or have had in the recent past, active development studies underway.

  - Ability to provide a representative to the Concept Development Team that possessed a high level of expertise in a particular aspect of a total mineable tarsands scheme and/or a high level of general tarsands project knowledge.

- The Techman president, a Mancal representative, and Mr. Wirth have met with Mr. Leitch, Minister of Energy for the Province of Alberta, for the purpose of familiarizing him with the objectives of the study and the approach being taken. He was invited to provide an Alberta Government participant. Mr. Leitch indicated that he would take the matter under advisement and develop it within his department and other affected agencies. To date, we have not had a response from him.

- In addition to the study results being reported to the Federal Government, EMR Department representatives, both Provincial and Federal Governments at the appropriate political levels will be kept appraised of the study findings and results as the work progresses.

Mr. Guthrie asked whether the study and Techman's assignment would be announced publicly. Wirth advised that the Prime Minister's office has prepared an announcement, but as of now we do not know when and if it will be released.

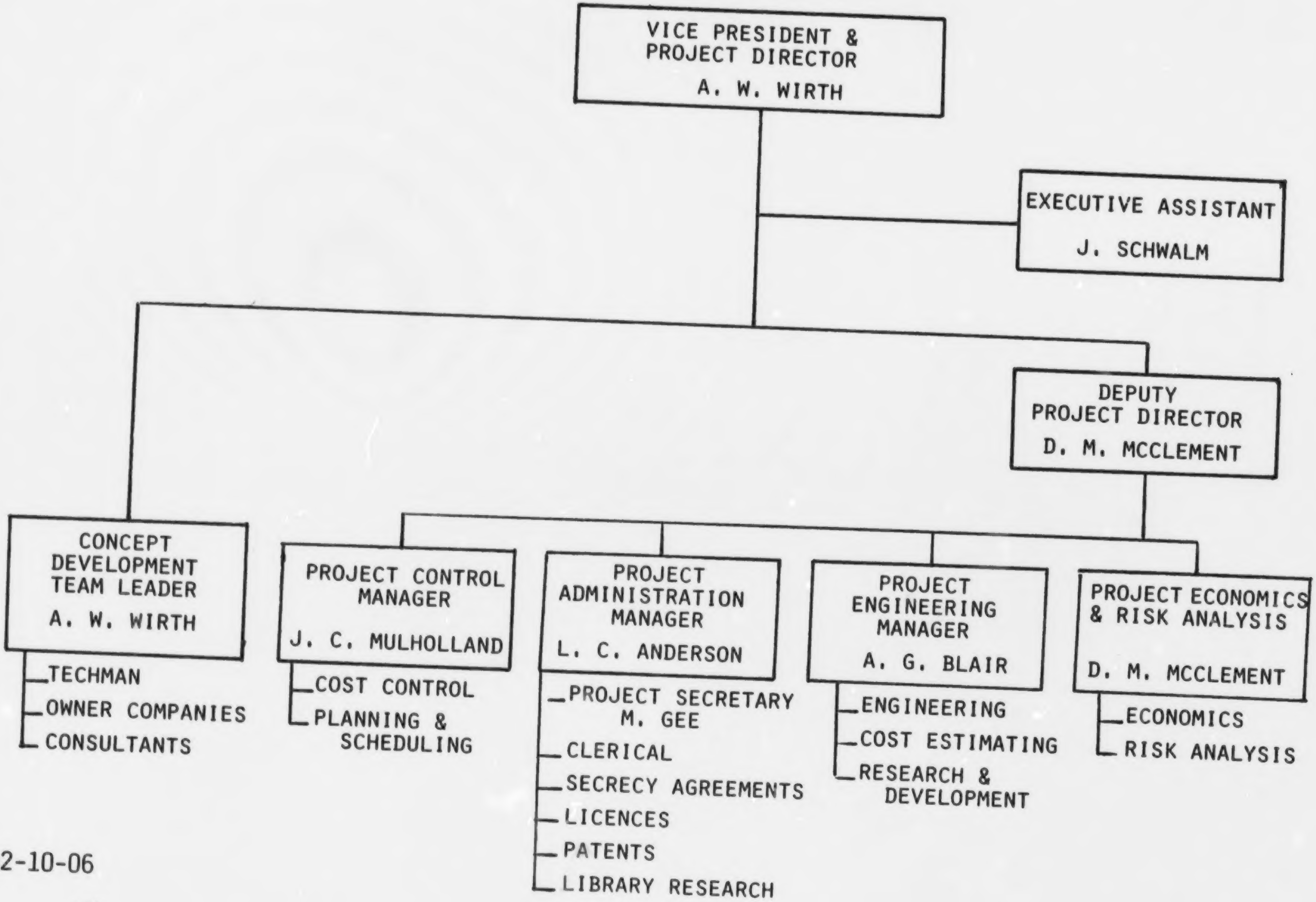
Al Hyndman requested that copies of the viewgraphs used during the sessions be included with, and form part of, the Minutes. This was agreed to.

Using the following Organization Chart (see Page 6) Messrs. McClement and Wirth described the Tarsands Development Study Organization Structure.

...6

ORGANIZATION CHART

TAR SANDS DEVELOPMENT STUDY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CONCEPT DEVELOPMENT TEAM LEADER
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LICENCES
PATENTS
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ENGINEERING
COST ESTIMATING
RESEARCH & DEVELOPMENT
PROJECT ECONOMICS & RISK ANALYSIS
D. M. MCCLEMENT
ECONOMICS
RISK ANALYSIS

82-10-06

Wirth advised that the intent of Topics 2, 3, 4 and 5 was to ensure that the Concept Development Team members understood the prepared draft material. They were encouraged to ask questions of understanding. The detailed review, modifications as necessary and acceptance would be addressed as part of Topics 7 and 8.

2. DRAFT GENERAL STUDY OBJECTIVES (Stages 1 and 2)

Wirth presented and reviewed the proposed General Study Objectives as shown on Page 8. Questions were responded to. The Concept Development Team again reiterated their opinions that the study not be restricted to technical considerations. It was concluded that the General Study Objective as worded provided sufficient scope.

3. PROPOSED SPECIFIC STAGE 1 OBJECTIVES AND TASKS

Morris McClement reviewed the Proposed Specific Stage 1 Objectives and Tasks using viewgraph material as shown on Pages 9 to 14.

Questions of understanding were answered.

4. OVERVIEW OF THE SCOPE AND THE PROPOSED APPROACH TO THE STUDY (Stages 1 and 2)

Using the viewgraph shown as Page 15, Morris described the Study Scope of Stages 1 and 2 as well as the Proposed General Approach for the Study.

5. STAGE 1 PRODUCT - REPORT AND SEMINAR MATERIAL

Morris McClement using the viewgraph copied as Page 16, explained the probable contents of the Stage 1 Final Report. He also advised that presentations would be made to government-selected audiences covering the Stage 1 conclusions and the study plans for Stage 2.

- LUNCH BREAK -

(DRAFT)

GENERAL STUDY OBJECTIVE (STAGE I & II)

TO DEFINE ONE OR MORE SURFACE MINEABLE OIL SANDS DEVELOPMENT SCHEMES, ADDRESSING CONSIDERATIONS OF ALTERNATIVE TECHNOLOGIES, SCALE, OWNERSHIP AND STRUCTURE, GOVERNMENT POLICY AND PRACTICE, REGIONAL AND INDUSTRIAL BENEFITS, NATIONAL BENEFITS, ETC., THAT IN THE ANTICIPATED OPERATING AND MARKET ENVIRONMENT ARE ECONOMICALLY VIABLE, FINANCABLE, ACCEPTABLE FROM A RISK STANDPOINT AND MANAGEABLE.

A SECONDARY OBJECTIVE IS TO IDENTIFY POTENTIAL TECHNOLOGY ENHANCEMENTS THAT WOULD SIGNIFICANTLY IMPROVE THE BEST SCHEMES AND DEVELOP PLANS TO BRING THE IDENTIFIED POTENTIAL TECHNOLOGY ENHANCEMENTS TO A LEVEL OF COMMERCIAL AND INDUSTRY ACCEPTABILITY.

OBJECTIVES

1. To identify the characterizing features and constraints of a "Mega-Project" and "Modular-Project" approach to development of a tarsands property. Document, for the Mega-Project, the significant parameters such as Capital Cost per Daily Stream Barrel, Total Cost, Cash Flow Profile, Environmental Considerations, Available Technology and any other significant descriptive parameters.

2. To identify the economic, operational and technological criteria for a modular scale project and state these in the form of absolute and desirable requirements.

3. To identify probable schemes for examination (for example, a 15,000 BPD module) and outline a development scenario including prelimimary budgets and schedules, to test the schemes versus the criteria previously established. The operation to be examined will primarily be those within the mine fence although energy and operational integration with downstream units will be taken into account. The analysis will typically demonstrate the effects of size, financing, and capital investment arrangements (for example, cost of service or sale of product) on all cash movements throughout the life of the plant.

4. To select surface mineable tarsand development schemes that demonstrate a probability of success, and develop a study program for detailed evaluation and ranking of the selected schemes.

5. To prepare presentation material to display the preliminary conclusion and proposed future study program, to audiences selected by the government.

TASK DESCRIPTION

1. ASSEMBLE AND MOBILIZE

a) Assemble the Concept Development Team

b) Review of Project Objectives

The objectives of the study will be reviewed by the Concept Development Team to ensure a broad understanding as to the basis for the remaining work.

c) Review of Methodology

The methodology described in this statement of work will be reviewed by the Concept Development Team to ensure the objectives will be achieved, or to modify the study methodology, if required.

2. COMPILE DATA TO DESCRIBE TRADITIONAL MEGA-PROJECT

a) Identify characterizing parameters

Identify and list significant characterizing parameters including economic and technological factors. Document the source of all data. Probable parameters include the following:

- Total Cost (brought to a Common Base)
- Cost per Barrel of Production
- Development Time
- Plant Complexity, Redundancy, Reliability
- Applied or Planned Technology
- Ownership - Private, Government, Multiple Parties
- Financing Constraints

b) Quantify the Identified Parameters

By engineering analysis, literature search and analysis of historical data, apply numbers, descriptions or other rational measures to the identified parameters, for subsequent comparison.

3. LIST "MUSTS" AND "WANTS" OF A MODULAR, SMALLER-SCALE PROJECT

Identify the factors which must be present and the characteristics which must be designed into a successful, viable, alternative and smaller scale project. The total range of criteria considered and the proceedings and arguments leading to the conclusions; i.e., the final list of "Musts" and "Wants", will be documented. The rationale for inclusion or omission of criteria will be fully and completely documented. A basic list of "Musts" and "Wants", to be confirmed or augmented and quantified is:

"Musts"

- Capital Cost not to exceed $
- Cost per Daily Stream Barrel to be no more than $
- Overall Development Time from Approval to Production not to exceed years.
- Scale-up Risk generated by new technology to be at a level acceptable to private investors.
- Meet all Alberta Energy Resources Conservation Board Recovery Guidelines, as they are anticipated to exist in the next decade.
- Meet all Department of Environment Regulations as they are anticipated to exist in the next decade.
- Extracted Bitumen or Synthetic Crude to have a feasible upgrading and/or processing scheme, and be acceptable to potential upgraders or consumers.
- General suitability to a high percentage of mineable tarsands and specifically suitable to at least one site.

"Wants"

- Modularized Development Program
- Offsite Preassembly Program
- Sand Tailings returned to mine without substantial movement, storage or rehandling.
- Engineering Management, Design, and Construction Force can be mustered for long-term development without disruptions to provincial economics or social structures.
- Sole Canadian Ownership Potential

- Degree of Direct Government Involvement in Financing, not to exceed
- Ownership Scope opened to a wider body of Potential Operators

4. IDENTIFY ALTERNATE PROCESS COMBINATIONS TO BE EXAMINED

Identify Alternate Development Schemes, comprising Mining, Extraction, and Upgrading Components, that appear at the outset, to have high probability of success, and list for each all the characteristics and parameters required to make a preliminary economic and technical evaluation. The rationale for including these alternate schemes and for discarding others will be documented.

Items to be considered and/or quantified will typically include for each development scheme:

- Size
- Types of Mining Schemes
- Type, Size, and Location of Extraction Unit(s)
- Type, Size, and Location of Upgrading Facilities
- Method of Handling Tailings
- Degree of Energy Integration
- Overall Energy and Utility Balances
- Environmental and Social Considerations
- Technological Risks

5. DEVELOP ESTIMATES

a) Estimate preliminary costs of identified development schemes using curve-type data from the literature, licensors data, and if available, historic cost data.

b) Determine the appropriate level of estimating accuracy and rationalize all estimates to this basis.

6. DEVELOP PRELIMINARY PROJECT SCHEDULES

a) Using historical data, develop preliminary planning level schedules for each development scheme.

b) Integrate the schedule with the estimating data to obtain pro-forma cash profiles for each development scheme.

7. MAKE PRELIMINARY EVALUATION OF ALTERNATIVES

a) Using cost and schedule data and other descriptive operating and performance data outlined in Task 4, test each of the proposed alternate development schemes against the "Musts" identified in Task 3. Discard any which do not meet the criteria.

b) Rank all of the remaining schemes in accordance with their viability versus the "Wants" listed in Task 3.

8. SELECT MOST PROBABLE ALTERNATIVES FOR DETAILED EVALUATION

Review the provisionally selected alternate schemes. Based on indicated success versus the viability criteria, and considering technological risk, select those schemes to be evaluated in detail in Stage 2 of this project. Schemes selected at this time will probably include those feasible with present technology as well as those carrying a technological risk that may be justified by potentially superior performance, and schemes requiring pilot or demonstration plant work to commercially demonstrate the technology. The rationale for selection will be completely and fully documented, the measure of each alternate scheme against the selected performance criteria will be recorded and the residual risk will be assessed.

9. DEVELOP PROGRAM FOR DETAILED EVALUATION

a) Develop the specific objectives and work statement for a Study Plan to evaluate the alternate schemes selected, in a detailed comprehensive manner. Determine the specific methodology to be used in subsequent stages, including the required accuracy of estimates and other data. Develop the engineering manpower, cost estimates and schedule for Stage 2 activity.

b) Review Stage 2 Plan with Techman/Loram Management and the Concept Development Group.

10. DISPLAY RESULTS

a) Prepare presentation material and summary reports documenting the results and recommendations from Stage 1.

b) Prepare presentation material, outlining the proposed Stage 2 program.

c) Make presentations to the government and to audiences selected by the government.

SCOPE OF STUDY

1. STAGE 1 SEPTEMBER 9, 1982 to DECEMBER 15, 1982
    a) Concept Development Team Activities
    b) Evaluation Activities

2. STAGE 2 DECEMBER 15, 1982 to AUGUST, 1983
    a) Development and Optimization of Designs
    b) Detailed Evaluation of Schemes
    c) Selection of Optimal Schemes
    d) Presentation of Results

FINAL REPORT

1. Description of a Typical Mega-Project

2. Summary of Deliberations of Concept Development Team

3. Project Viability Criteria

4. Summary Conclusions - Screening level description of provisionally selected development schemes

5. Stage 2 Execution Plan
   - Objective
   - Work Statement
   - Organization
   - Schedule
   - Budget

6. PROPOSED ROLE OF THE CONCEPT DEVELOPMENT TEAM

Attachment IV of Wirth's letter of September 29, 1982, to the Concept Development Team members outlined the proposed role of the Concept Development Team. Speaking from that attachment he reviewed the following proposed role:

1. From October 7 to October 29, 1982
   a) Review/Modify/Accept Study Objectives (General and Specific for Stage 1)
   b) Review/Modify/Accept Overall Study Approach and Methodology (tasks)
   c) Review/Modify/Accept Results of Task 2 Work done by Techman
   d) Task 3 - Develop "Musts" and "Wants"
   e) Task 4 - Identify Alternate Schemes to be Considered
   f) To the extent possible test the Options against the "Musts" and "Wants"/Modify as necessary the "Musts" and "Wants"/ Discard some Options/Identify Additional Options

2. From November 1 to the end of Stage 1, the Concept Development Team will function as an Advisory or Steering Committee, meeting as necessary to:
   a) Review/Modify/Endorse Results of Work done by Techman, etc., on Tasks 5, 6, 7, 8 and 9
   b) Review/Modify/Endorse Stage 1 Report and Planned Seminar Presentation Material

3. For Stage 2, the role of the Concept Development Team would be developed as part of Task 9.

The group took no exception to the role of the Concept Development Team as proposed.

7. REVIEW/MODIFY/ACCEPT STUDY OBJECTIVES

The General Study Objective (Stage 1 and 2) as proposed and covered under Topic 2, and the Specific Objectives for Stage 1, as proposed and covered under Topic 3, were reviewed and received thorough discussion. Both the General Study Objectives and the Specific Objectives for Stage 1 were accepted by the Concept Development Team.

8. REVIEW/MODIFY/ACCEPT OVERALL STUDY APPROACH AND METHODOLOGY (TASKS)

The 10 Tasks as covered by McClement in his presentation on Topic 3 were thoroughly reviewed and discussed. Understanding by the group was achieved and it was agreed that they generally provided a framework and a structure for the required work. It was also agreed the General Approach to the study as covered under Topic 4 was reasonable. The group reiterated their opinions that due importance needed to be given to the non-technical aspects of the study. Wirth assured them that this would be so.

9. PRESENTATIONS AND DISCUSSIONS ON THE CURRENT STATE OF THE "ART" AND POTENTIAL APPLICATION IN THE FOLLOWING AREAS:

a) Mining

Jim Abbott reviewed his concept of a mining scheme that would minimize haul and/or conveyor distances utilizing the main truck and shovel equipment. Jim feels that his scheme would mine and handle tarsands in a volume that would probably be optimum at a 45 - 50,000 barrel per day synthetic crude operation. It was concluded that this would be one of a number of mining schemes that would be identified and evaluated.

b) Extraction

The discussions on the State of the Art as it related to bitumen extraction from tarsands were led by Messrs. Porteous, Rose, Devenny, and Hyndman.

Both the Syncrude and Suncor plants extract bitumen from the tarsands using the Clark Hot Water Process. At this point in time it is the only available commercially demonstrated processing technology. It is an energy-inefficient process, utilizing recycled water. Because the tailings are wet, a tailings pond is required. The advantages and disadvantages of the process are shown on Page 19.

EXTRACTION
CLARK HOT WATER PROCESS

ADVANTAGES

- SIMPLE PROVEN PROCESS
- RECOVERY GOOD
- MATERIALS HANDLING EFFICIENCY
- AMENABLE TO IMPROVEMENT
- LOW COST
- LOW CHEMICAL CONSUMPTION
- LOW WATER RATIO

DISADVANTAGES

- HIGH TEMPERATURE WATER
- DIRECT STEAM INJECTION
- POOR PROCESSABILITY ON LOW GRADE, HIGH FINES FEED
- TAILINGS POND REQUIRED
- SLUDGE ACCUMULATION

EXTRACTION

ALTERNATIVE TECHNOLOGIES

- DIRECT THERMAL
  - LURGI
  - TACIUK
- SOLVENT ASSIST

  SESA (SOLVENT EXTRACTION/SPHERICAL-AGGLOMERATION)
  - DRAVO
  - MAGNA
- MODIFIED HOT WATER
  - RTR (RIO TINTO)
  - KRUYER
  - SYNCRUDE 2-STAGE

ALTERNATE EXTRACTION

COMPARATIVE CONSIDERATIONS

	LURGI	TACIUK	SESA	RTR	DRAVO*	SCL (2)	KRUYER
DRY TAILINGS	✓	✓					
RECOVERY	✓	✓	✓	(✓)	✓	✓	✓
LOW GRADE OIL SANDS	✓	✓	✓		✓		✓
HEAT EFFICIENCY	✓	✓	✓	✓	✓	✓	
SLUDGE REDUCTION	✓	✓	✓	✓	✓		(✓)
RETROFIT TO CLARK			(✓)	(✓)		✓	✓
SOLVENT LOSS			✓		✓		
SIZED FEED	(✓)	(✓)	(✓)		*		✓
PILOT ADVANCED	(✓)	✓	(✓)	✓	*	(✓)	(✓)
NOVEL EQUIPMENT	✓	✓	✓	✓	✓	✓	✓

* NO INFORMATION

Syncrude has developed modifications to the Clark Hot Water Process. These modifications improve recovery and reduce the mechanical complexity. Other modified Clark Hot Processes in varying stages of development are the RTR and Kruyer Processes. These processes are aimed at improving recovery, decreasing energy demand, and producing a dryer waste. The key objective of the improved extraction process is to eliminate progressive generation of expanding clay sludge.

Other alternative unproven technologies can be grouped into two other basic classifications; namely, "Direct Thermal" and "Solvent Assist". Page 20 shows the processes in each of the three basic classifications. Page 21 illustrates comparative considerations for each of these potential extraction processes.

The Concept Development Group agreed that there was considerable incentive to develop extraction processes that do not produce excessive sludge, that are more energy efficient and would give better bitumen recoveries. Reducing energy requirements and improving recovery would also be very desirable.

The group concluded that for the next 5 to 10 years the Clark Hot Water Process, or some derivative thereof, would likely be the selected extraction scheme. Over the longer term, considerable enthusiasm was expressed for the Direct Thermal (Retort) Processes; namely, "Taciuk" and "Lurgi". Taciuk is being piloted in Calgary and Lurgi have a pilot operation in California.

The group also agreed that for a smaller scale tarsands operation the risk considerations take on a different dimension and a Retort Process might well be deserving of evaluation, depending on developments over the next few years.

The results of the extraction technology studies being conducted by Dynawest for the ERCB will be available to the study team when the reports are completed. (Mr. Evans noted that the ERCB would summarize the Dynawest report by mid 83 for public use).

It was also pointed out that chemical electric separation, which would require large scale piloting, would potentially eliminate the centrifuge step in the hot water process.

For reference in considering atmospheric emissions, Al Hyndman handed out a curve illustrating SO_2 emission standards for different plants (see attachment).

Al Hyndman distributed, and commented on, a paper that had been published in the Economic Journal entitled "Uncertainty, Risk Aversion and the Taxing of Natural Resource Projects".

UNCERTAINTY, RISK AVERSION AND THE TAXING OF NATURAL RESOURCE PROJECTS[1]

RISING prices of foodstuffs and natural resources associated with pressure on world energy, minerals, fish and forest resources in recent years have provided new economic opportunities for many developing countries. Production of commodities from natural resources has become profitable in new locations which are further from markets or more costly to operate. At the same time, established resource-based industries have become very much more profitable.

Industries based on cheap sources of energy or producing fuels and minerals are typically capital-intensive and, in a developing country, they have limited scope for local purchase of supplies. Hence, whatever national benefit is to be derived from them must come mainly through taxation. The central task of economic management in the resource-based industries is thus to maximise the contribution that these industries make to government revenue. This task has two aspects: ensuring that the resources are used in ways that maximise long-term social product, and capturing for the public as large a proportion as possible of the benefits generated.

This paper analyses the problem and suggests a new approach which, in a national economy whose major resource projects are financed externally and therefore do not compete for funds with other types of investment, appears to do less to reduce efficiency in the use of resources than any alternative taxation system. If applied in its hybrid form with normal company income tax, the suggested approach appears to do less to reduce efficiency in the use of resources than alternative taxation systems in any economy. At the same time, in any but the most predictable and stable economic environment, it can secure for the government a higher proportion of super-normal profits from each resource than most other taxation systems. The only taxation systems that might secure for the government a higher proportion of super-normal profits from established projects require *ex post* adjustments to the terms upon which investments are made and so, by increasing investor uncertainty, reduce the revenue to be expected from new projects and from extensions of existing projects.

THE PROBLEM OF TAXING RESOURCE PROJECTS

Control of the terms of access to natural resources gives governments the power to extract Ricardian rent from the use of these resources. If there were no prospect of further investment in existing or new natural resource projects, the taxation problem would involve raising rent charges to the highest level consistent with the continuation of existing projects. In an economy in which there are prospects for expanded investment in natural resource projects, however, and in which the profitability of future investments is not known with certainty, maximising total government revenue involves balancing the possibility of revenue loss on highly profitable projects through an over-liberal approach against the possibility of setting rent charges so high that there is revenue loss through deterrence of projects which, *ex ante*, are not certainly intra-marginal.

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[1] The authors are grateful to the following people who kindly read one or other draft of this article and provided critical suggestions or encouragement or both: Richard Caves, Andrew Gordon, Gordon Goundrey, Russell Matthews, Edith Penrose and Herbert Qualls.

Through this paper we use the term "rent" in a slightly unusual way, as the profits that remain after deduction of the company income which corresponds to the minimum return necessary to attract private investment to new projects. Thus the "rent" generated by exploitation of a resource is a function of the efficiency with which it is exploited and of any factors that affect the rate of return necessary to attract investment. We use the term "supply price of investment" to describe the minimum expected rate of return (the minimum weighted average of possible outcomes, with weightings reflecting the probability of each outcome's occurrence) that is consistent with a decision to invest.

The "supply price of investment" and "rent" are thus behavioural concepts. The supply price of investment is a function of normal, competitive returns to investment, of the degree of monopoly in the industry, of the degree of economic and political risk associated with a project, and of investors' attitudes to risk. The literature on foreign investment in resource industries in the developing countries stresses investors' oligopolistic organisation which is described in qualitative terms, but it is singularly weak on the quantitative effects of this on profits. Competition among the oligopolists controls to some extent the levels of profits in the resource industries, and relatively sophisticated techniques of computing profitability are widely used as aids to profit maximisation. Variations in approach remain, however, and governments negotiating with investors have little information on variations in the supply price of investment.

A government seeking to extract the highest possible proportion of the "rent" must assume some behavioural characteristics of investors, and potential revenue will be wasted if there is serious divergence between their assumed and actual motivation. Many major investors evaluate projects on the basis of expected internal rate of return on total cash flows.[1]

Investors' objective functions are non-linear with respect to profit unless an investment is very small relative to the total operations of an investor. Risk aversion is likely to be associated with any investment that is large relative to the total operations of a firm, since the negative value of total failure, which could have major adverse effects on the standing of high-level company personnel and on the parent company, is likely to weigh more heavily than the positive value of unusually large profits. If there is a risk of substantial failure, the firm will not invest under *ex ante* arrangements that would leave expected profits equal to the supply price of riskless investment. In addition, the firm will not invest under *ex ante* arrangements that provide a substantial possibility that profits will be well below the supply price of riskless investment, even if *expected* profits are significantly above this price. Some large investors take risk into account in a crude way by requiring the investment to yield a certain rate of return on "safe" *ex ante* estimates of production costs and product prices. A high degree of political risk is taken into account by some firms through a shortening of the "pay back" period, that is the number of years whose income and expenditure streams are considered in calculation of profitability. This has the effect of raising the supply price of investment in a way that depends very much on the timing of profits and taxation.

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[1] See, for example, John F. Helliwell, *Taxation and Investment: A Study of Capital Expenditure Decisions in Large Corporations* (Studies of the Royal Commission on Taxation, Number 3, Ottawa 1966), pp. 12-15; John T. Ralph, "Feasibility and Financing", paper delivered to Australian Society of Accountants and Institute of Chartered Accountants Joint Seminar, *Special Accounting and Financial Considerations Relating to Mining and Exploration Companies* (Sydney, 27 Sept. 1971).

A private investor seeks to avoid any significant probability of very low or negative rates of return in a large project, but there is probably always some trade-off between increased risk of failure and the prospect of very high returns. Any taxation, even if it is confined to very high profits, may have some deterrent effect on investments which, *ex ante*, are not obviously intra-marginal: however, the degree of deterrence is clearly less the more the incidence of taxation is concentrated on profits that represent a high rate of return on investment and the more it is concentrated in later years.

Two other behavioural characteristics are assumed in the arguments upon which the taxation proposals in this paper are based. First, investors assess political risk, and the stability of negotiated taxation systems, by reference to *ex post* treatment of established investments in the country. Second, very high marginal profit tax rates remove incentives to efficiency and consequently reduce the rent available to be collected. The first characteristic causes *ex post* adjustment in one project to affect *ex ante* expectations of the after-tax profitability of future projects. *Ex post* adjustments that are based on clearly articulated principles might, in principle, cause new investors to expect consistent treatment, but in reality the fact of *ex post* adjustments would probably contribute to some uncertainty about the stability of all systems within the country, and, given investors' aversion to risk, would probably raise the supply price of investment and lower the "rent" in new projects. The second behavioural characteristic prevents the capture under conditions of uncertainty of the whole of the "rent" available from the efficient exploitation of a resource. This would be true even if attempts were made to extract the "rent" by fixed fee or *ad valorem* or specific royalty systems applied *ex post*, provided only that such systems were anticipated *ex ante* by new investors.

The complexity of the "rent" concept and the government's ignorance in any particular case of the supply price of investment make the balancing of revenue loss through over-liberal approaches to taxation against revenue loss through deterrence of new projects extremely difficult. Provided each project were given its own set of tax and royalty rates, the rent problem would be simple if there were perfect knowledge on the part of the government about the supply price of investment and no uncertainty about production costs or product prices. Lump-sum fees or royalties could be set in advance of investment for each project at levels that left the rate of return equal to the supply price of investment. Taxes and charges could be expressed for each project in absolute amounts or as a percentage of turnover or profits. This approach is less useful the greater the uncertainty about profitability. The problem is greatest when information available to the investor is also superior to that available to the government, but, under conditions of uncertainty, risk aversion introduces problems even with equal information.

We shall look first at the problem as it would exist if the government and the investing company had identical information on costs of production, prices of products, and the supply price of investment. If there is uncertainty about future profitability, risk aversion causes the supply price of investment to rise if a project is subject to *ex ante* lump-sum rent charges, specific or *ad valorem* royalties on production, or proportional taxes on profits. This is because prior taxes that are proportional to the volume or value of production or to company profits raise the risk of failure or of unacceptably low returns and hence raise the level of expected after-tax profits that will induce investment.[1] For a project that seems *ex ante* to be possibly marginal in the absence of any tax, the rates of such uniform percentage profits or turnover taxes would need to be set at negligible levels if the investor were to consider the investment worth undertaking. But such a "marginal" project might *ex post* earn high returns. With negligible rates of tax, unexpectedly high profitability would of course produce negligible revenue for the government. This problem can only be overcome by a system of taxation that does not add to the risk of failure or of unacceptably low returns, and yet is still capable of reaping a generous share for the government if returns turn out to be high.

The problem is increased if the firm has superior access to information on price movements and costs of production. In this case, even in the absence of risk aversion, the government may be impelled through ignorance to accept revenue arrangements that would leave expected profits above the supply price of investment. The pattern of risk aversion on the part of the investor, which affects the supply price of investment, is a further parameter on which the investor is likely to be better informed than the government.[2]

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[1] This is true even of an ordinary profits tax since, for example, the tax will normally begin to be collected before the investor has recovered the value of his investment with an acceptable rate of return.

[2] In some circumstances the government can take steps to restrict the reduction in "rent" associated with the investor's risk aversion. It can reduce the size of the investment to individual

If the supply price of loan capital to the government is below the supply price of investment, the net present value of government revenue is increased by allowing revenue charges to be concentrated in later years of the project (rather than extracting earlier a stream of charges which from the viewpoint of the investor is equivalent) and borrowing to maintain desired levels of general expenditure in the earlier years. The advantage to the government of concentrating revenue charges in later years is further increased if investors perceive political risk and ignore or discount at a very high rate the income of later years.

The degree of uncertainty associated with production costs depends upon the point in time at which an agreement is entered. Investor risk aversion makes it desirable for the government to delay agreement as long into the exploration and assessment period as is possible. But exploration and feasibility studies are expensive, and investors will be unwilling to invest heavily in these activities without some indication of the terms upon which the resource can be developed. It follows that a fixed system of tax provides more encouragement to investment in exploration than a system of *ad hoc* arrangements. The problem could be overcome in principle by direct government involvement in exploration and assessment. For most developing countries this would be inefficient, even though in some circumstances assistance in these activities can be purchased or obtained as aid.

Production costs per unit of output remain uncertain even after detailed feasibility studies, and in many cases after production has begun. Sampling procedures are imperfect and the size and quality of the resource cannot be ascertained in advance of its exploitation. The cost of infrastructure is uncertain before construction, especially in high-rainfall country and swampy or mountainous terrain. Uncertainty about unit production costs is reduced if the scale of the investment is variable after production has begun, as in fishing, where underemployed boats can be withdrawn, or logging, where machinery can be used elsewhere. But short-term reduction in the scale of investment is impossible, or possible to a very limited degree, in mining or in the use of hydro-electric potential.

It would greatly facilitate the solution of the taxation problem if there were a high degree of certainty about unit production costs. A set of price

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parent companies by promoting consortia, by borrowing to provide infrastructure, or by borrowing to purchase equity. Such measures may increase the amount of rent available to be taxed. The government's overall expected revenue position, however, is not certain to be improved by the provision of infrastructure unless it can borrow at a rate no higher than the rate of return which the company requires after tax from the modified project, and unless it is rewarded with equity in proportion to its expenditure on infrastructure.

Incidentally, if loan capital is available to the government at a price lower than the rate of return after tax which the company requires, government provision of infrastructure or purchase of equity (provided again the equity reward is in proportion to the government outlay) will raise expected revenue yields even if investors are not averse to risk. The availability of loan capital from foreign governments and international agencies may make this an important possibility for developing countries.

levels that was necessary to attract investment to the resource (or to each part of the resource) could then be calculated, and the whole of income accruing from prices above that set of levels could be taxed away without loss of efficiency. But these circumstances are unlikely to occur, especially since the investor can expect to reduce rent charges by increasing the government's uncertainty about production costs.

Hence, in real-world situations, where there is a high degree of uncertainty about pre-tax profitability based on ignorance of costs as well as prices, a price-based system is inadequate, and a high proportion of the potential rents cannot generally be collected by governments except through a system of taxation that is based on both costs of production and prices considered *ex post*. A method for doing this is discussed in the following section.

Varying Tax-Rates with Rate of Return:
The Resource Rent Tax

Despite its theoretical attraction as a means of maximising government returns from natural resource projects, the variation of tax rates directly with rates of return is seldom used in practice. We believe that the Resource Rent Tax defined below is an efficient means of taxing natural resource projects where there is uncertainty about future production costs and prices. It is also simple in conception and practice.

The Resource Rent Tax is briefly a profit tax that begins to be collected when a certain threshold internal rate of return on total cash flow has been realised.

The starting point for assessment is an annual quantum called "net assessable receipts", which is simply the sum of all receipts in respect of the establishment and operation of the project, less the sum of all corresponding payments. In the terminology of this paper, net assessable receipts in any year are simply the excess of all "assessable receipts" over "deductible payments" in the year. The latter concepts are defined more precisely below.

The principle of Resource Rent Tax is to take a threshold rate of x % (it might be 10 % or 15 % for instance) as an interest rate, and each year calculate the value of net assessable receipts from the beginning of the project accumulated at that interest rate. The process involves in each year raising the accumulated value at the end of the previous year by the interest rate, and adding to this the current year's net assessable receipts.

A positive accumulated value would, of course, indicate that an internal rate of return in excess of x % on funds committed to the project had been realised, and the excess would be taxable at a % (which might be 50 %).

In order to avoid double taxing, the positive net accumulated value for any year on which the Resource Rent Tax had been assessed would be deducted from the assessable receipts of that year for the purpose of calculating the net accumulated value for tax purposes in future years.

If it were desired to tax beyond higher profit-rate-thresholds at higher rates than a %, the process of finding the accumulated value of net assessable receipts in each year could be repeated with the higher threshold, y % (say 20 %), as the rate of interest. Any positive accumulated value at the y % interest rate could then be taxed additionally at b % (which might be 25 %), with the provision against double taxation already explained.

The steps of this process are given in detail in an appendix.

The total effect of the system would be to tax company returns in excess of x % (after company tax and royalties, if any) at a rate of a %, and returns in excess of y % at a rate of $(a+b)$ %. If it were thought desirable, further graduations could be introduced so that returns in excess of z % could be taxed at a rate of $(a+b+c)$ %. The accumulation of net assessable receipts at a given interest rate ensures that the timing of a company's income and expenditure has no distorting effect on the internal rate of return at which it becomes liable to Resource Rent Tax.

"Assessable receipts" would need to be defined as covering all receipts of the operating company other than receipts in the nature of provision of capital or repayment of capital. They would thus exclude the value of loans and shareholders' funds received, and the value of loans repaid to the company by any other entity. They would include the receipts from sale of depreciated, obsolescent, or any other, assets formerly purchased for use by the company. Rewards for the provision of capital would be non-existent because of other limitations (described below) imposed on the operating company.

"Deductible payments" would need to be defined similarly as covering all payments by the company other than payments in the nature of repayment of capital, provision of capital or rewards for the provision of capital. They would thus exclude repayments of loans, payments of interest, dividends and bonus issues. They would not include past payments of Resource Rent Tax. They would, however, include payments of any tax other than Resource Rent Tax.

With a few exceptions that can be specified, the definitions of receipts and payments that are used in the assessment of company income tax can be used in the assessment of the Resource Rent Tax. The most important exceptions relate to the special treatment of interest payments and of depreciation, described above. Increases in stocks of unsold raw materials would not be assessable receipts, and it would be necessary to specify the time at which sales become assessable receipts. Either the time of physical export or the time of physical receipt by the purchaser would be appropriate. The income tax definitions of deductible payments would need to be limited, in the case of payments in respect of contracts, to payments for services rendered in the relevant accounting period. Deferment of liability for taxation through early payment under longer-term contracts for services occurs with conventional income tax as well, especially in transactions among affiliates, but the cost to the revenue of early payment would be greater with Resource Rent Tax.

The accumulation of costs and receipts at a specified interest rate is a novel element in a taxation system. However, the overall operation of the Resource Rent Tax in its most simple form, with one interest rate and one threshold, would be similar to that of a company profits tax with the following features:

(i) no deduction from taxable income for interest payments,

(ii) an immediate 100 % depreciation or amortisation of all expenditures on investment (which are thus treated in the same way as current expenditures), and

(iii) an unlimited carry-forward of losses, bearing interest at a specified rate.

? cf Sask- [illegible] [illegible] royalty system

So long as other systems of profit tax apply to other kinds of enterprise, the application of the Resource Rent Tax (RRT) would require the operating company so taxed to have its operations confined appropriately, probably to activities associated with production and sale of the raw material (or semi-finished product in the case of smelting industries based on cheap hydro-electricity). To make this provision effective, the operating company would need to be forbidden to make any loans other than interest-free loans or to buy equity in any profit-making entity. Management of its financial reserves would have to be carried out by a resident affiliate to which it would make interest-free loans and which would be subject to the normal company tax. Without some such provisions as these the dual tax system would give opportunities of avoidance. Standard income tax definitions relating to the termination of the "resource production" phase could be used to exclude treatment and other operations unrelated to the extraction of raw materials, at least in the case of mining projects, if this limitation were considered the appropriate one.

The problem of defining the operational phase of a resource project that is subject to Resource Rent Tax also arises at the exploration end of a project. Exploration, in its early stages the most risky investment related to resource projects, can be treated in several ways. The logic of the Resource Rent Tax is probably preserved best by allowing all expenditure undertaken by a company on exploration within the country before the signing of a project agreement to be treated as a deductible payment against income generated in the first project operated by the company. This procedure reduces the risk associated with early, general exploration. The limits of the first project would be defined at the time that an agreement was signed, and further exploration expenditure unrelated to the first project would be deductible only against future projects. This restriction is necessary because companies operating existing projects would receive an unrequited competitive advantage in exploration if they were permitted deductions for subsequent unrelated exploration. They should, however, be allowed deductions for expenditure on further exploration within the limits of an existing project.

The effective application of RRT, like that of other profit taxes, would require surveillance of prices received by the company for its products, whether they were sold domestically or overseas, and of prices paid for equipment and materials. "Arm's length" prices would need to be enforced in transactions between the company and processing affiliates that were not subject to RRT or not included with it for tax purposes.

The rent of government-managed hydro-power resources used for privately-owned smelting and refining projects might be efficiently extracted by taxing the projects by RRT and selling power to them at cost.

The RRT system prevents the company from exploiting the government's relative ignorance about costs and prices, because it is based on revealed profitability. Furthermore, by raising the probability of the company's receiving moderate returns and lowering the probability of the company's receiving extremely high returns, "progressiveness" in the RRT under conditions of risk aversion lowers the expected after-tax profitability (and so raises the expected revenue charges) associated with a given company utility. By the same reasoning, investors' aversion to risk implies that a graduated scale of RRT will render acceptable to the company higher expected rent charges than a high, flat rate applied to all those receipts which would cause expected returns to exceed the supply price of investment. When one is setting the rates, a, b and c, and the profitability thresholds, x, y and z, it is of course the implied rates of return after payment of RRT that should be compared with the supply price of investment. Since the supply price of investment may not be uniform among industries or among investors or even among projects undertaken by the same investor in the same industry, and since it may in any case not be known precisely, there may be sense in exacting a moderate rate of tax (say 50 %) above a threshold near the lower end of the range within which the various relevant supply prices of investment are thought to lie, and exacting a high rate of tax (say 75 % or 80 %) above a threshold near the upper end of the range. Provided the lowest RRT rate is moderate, there may be no great loss of investment incurred by placing the first threshold actually below the supposed range of the supply price of investment. To adapt the RRT in this way in order to take account of ignorance, variation among project conditions, or even political demands made on other than strictly socio-economic grounds, need not vitiate its advantages over other forms of tax.

If the problem were to fix the rates for one project only, values for x, y and z, and for a, b and c, would be chosen to maximise the level of tax that was consistent with the particular company's decision to invest. If a general system were desired, either for all resource projects or for each industry, the rates would probably be set at levels expected to maximise overall tax receipts. This would, of course, entail a compromise between rates that were too lenient and those that were so severe as probably to discourage an undue proportion of potential projects. The rule might be modified if it were thought that any royalties and other similar charges made inadequate allowance for the general external diseconomies of resource investments. In that case rates and thresholds might be set in such a way as deliberately to discourage projec which in the absence of tax would be expected to be close to the margin of required profitability.

Rates of taxation could be extremely high in the later years of a highly profitable project without either encouraging the running down or disposal of assets or discouraging additional investment in exploitation of the natural resource. (In this the RRT would differ from company profits tax as usually assessed.) This is because any sale of assets would be counted as a receipt for RRT purposes, so that its value to the company would be reduced by RRT in just the same proportion as profits. Similarly the cost of new investment or maintenance expenditure would be reduced by the RRT in the same proportion as income earned on the investment is reduced. However, although a very high rate of tax on marginal profits would not promote disinvestment through the effect on returns to investment, the marginal rate would, of course, need to be kept significantly below 100% to maintain company interest in the efficient management of the project.

As defined above, the RRT is based on rates of return on total cash flows in the operation. It could be adjusted to vary with the rate of return on cash flows to equity holders. However, we favour using total cash flows since this method avoids arbitrary and unintended effects on the choice between equity and loan finance.

POSSIBLE DIFFICULTIES AND COMPLICATIONS OF RESOURCE RENT TAX

1. *Administrative*

The Resource Rent Tax would place an additional burden on the heavily laden taxation offices of the developing countries. However, the burden would mainly be that of learning to operate a new system. Accounting for the tax is straightforward (in fact rather more so than for conventional profits tax) because, to arrive at the annual net assessable receipts that form the basis of the cumulating process, almost all receipts and payments for a particular year are simply added. Assessment from the accounting data then follows a simple arithmetic principle familiar to accountants. Resource projects below a specified size could be taxed by more conventional methods, so that the projects subject to the Resource Rent Tax would be small in number and individually large enough in weight to justify any additional administrative cost associated with the application of the new system in a particular case.

2. *Exchange Rate Variation*

If the investor had doubts about the stability of the host country's currency, all calculations could be made in the currency of the investor, or in that of a country nominated by the investor. This might enable the government to fix rates of tax which would otherwise be unacceptable to some investors. The only requirement would be that the same currency be used throughout the calculations, with conversions at exchange rates ruling at the time transactions are made.

3. *Change in Purchasing Power*

Inflation may introduce some divergence between "real" and "money" rates of return. If the rate of inflation were constant and known in advance, this would present no problem for the construction of Resource Rent Tax, since it would require merely that the threshold rates of return (x %, y %) beyond which various rates of tax are charged be set so much higher than if prices were stable. Since, however, expected rates of inflation do vary over time, it is likely that the "supply price of investment" expressed in money terms will vary accordingly. This might be allowed for by relating the threshold rates of return (x %, y %) to some international long-term lending rate. Such a refinement would not be worth introducing unless it were thought likely to sway some investors who might be deterred by the prospect of fixed thresholds totally unaffected by varying rates of price change. If it were introduced, the threshold rates for new investment could be varied from year to year but, for each project, fixed for the life of the project at the rates appropriate at the time of the agreement or of the beginning of investment. Alternatively, the rates at which net assessable receipts are accumulated in a single project could vary from year to year. The former method would be more advantageous to the government in a period of rising bond rates and to the investor in a period of falling bond rates. Either approach would be satisfactory.

4. *Delay and Uncertainty in Revenue Receipts*

The Resource Rent Tax approach has disadvantages that would reduce its attractiveness in some circumstances. The concentration of revenue in later years might be a disadvantage for governments that did not have adequate access to international capital markets, and the greater expected revenue would be achieved at the expense of greater uncertainty about receipts from particular projects. However, these are not likely to be important disadvantages in an economy which has a number of resource projects at different stages of development. These disadvantages, if they existed, could be ameliorated in part by a hybrid approach to taxation, with Resource Rent Tax applied in addition to conventional company income tax. In this case, "deductible payments" in the calculation of RRT would include company tax payments. Under conditions of uncertainty and risk aversion, it would be necessary to balance this additional form of taxation by raising the threshold rate of return on investment at which the RRT began to be applied, and total government revenue to be expected from resource projects would be reduced. An alternative hybrid method of overcoming delay in revenue receipts is outlined in the following paragraphs.

RESOURCE RENT TAX WITH COMPANY PROFITS TAX

One other possible reason for applying company profits tax in some combination with Resource Rent Tax is that the home countries of the investing companies may treat the payment of RRT less favourably than the payment of company tax, particularly in years in which certain companies would (as might sometimes happen) be enjoying "tax holidays" under RRT that would be unusually long for company profits tax systems. For this reason it is probable that in some circumstances a company would gain if, instead of being subject to Resource Rent Tax, it were required to pay in any year *either* company profits tax *or* Resource Rent Tax, whichever was the higher, and then be permitted to rebate from future RRT liabilities (in any years and to the extent that they exceed company profits tax liabilities) the value, accumulated at some long-term bond rate, of all past payments of company profits tax that have exceeded Resource Rent Tax liabilities for the years in which they have been paid. This would ensure that it never in any year paid less than its liability under company profits tax, but that if profits were high it would not pay less over the life of the operation than was due under Resource Rent Tax. To allow for the possibility that because of overseas taxes a firm might have more incentive to invest under this system than under simple Resource Rent Tax, resource investors might be given the option to be taxed either in this hybrid way or by the pure form of the Resource Rent Tax.

Alternatively, if the problem of timing discussed in the second last paragraph were thought to be crucial, the second hybrid method might be made obligatory. It would maintain the full advantages of Resource Rent Tax for highly profitable projects, supposed in advance to be such, but would be somewhat less satisfactory for those thought in advance to be possibly marginal.

UNIFORMITY OR DIVERSITY OF RATES AND THRESHOLDS

The Resource Rent Tax could be applied at separate (perhaps negotiated or even auctioned)[1] rates and thresholds to each project, or to each industry, or at the one set of rates and thresholds over the whole economy. The tailor-made approach to rate-setting might raise returns from individual projects or lower the risk of marginal investments being deterred accidentally. Given the actual situations in which governments commonly find themselves, however, it is possible that negotiated thresholds and rates might be less favourable to the government overall than fixed thresholds and rates. There are advantages in administrative simplicity, reduced expenditure on information, reduced delays in projects, and increased business certainty, of the adoption of a single set of rates and thresholds. Where much has to be spent on exploration, prior certainty over the terms on which the resource can be exploited is of great value to the prospective investor. There are also gains to the government from a single set of rates and thresholds, at least in each industry, if it is not well equipped for bargaining over individual projects; and indeed the governments of less-developed countries rarely have access to the knowledge that is necessary for the exploitation of any special cases of unusually low investment supply price. There is, however, a case for separate, higher threshold rates in industries, such as petroleum and natural gas, in which investment in exploration is both highly risky and a high proportion of total investment.

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[1] There is evidence that auctioning of rights to resource exploitation may cause investments to be supplied at a lower actual price. (See W. Mead, "Cash Bonus Bidding for Mineral Resources", Conference on Mineral Leasing Policy, University of British Columbia, Victoria, September 1974.) But this is probably of limited application to metal extraction.

RESOURCE RENT TAX AND GOVERNMENT EQUITY

The use of Resource Rent Tax would remove or reduce one important motive for desiring government equity in resource projects: the desire to benefit from high returns. The advantage for the government in being able to get the benefit of high returns without actually purchasing equity is that it removes the risk of absolute loss that equity investment entails. Nevertheless, the desire for equity may persist for symbolic reasons, although the desire may be irrational in terms of more fundamental government objectives. One neat way of satisfying this desire is to trade equity for tax obligations. The equivalence between equity and tax obligations is probably easier to establish with the RRT than with conventional company tax. If the marginal rates of tax considered appropriate were, say, 50% after the first threshold and 75% after the second, an equivalent alternative would be to establish an option for the government to maintain the 50% marginal tax rate from the first threshold throughout but to receive in addition 50% of the private holders' equity when the second threshold is reached.

CONCLUSIONS

Returns on investments in natural resources are often highly uncertain; investors are averse to risk; and governments often have to depend on potential investors for information about the value of the resources. Thus investors in resource projects may feel obliged to insist on tax regimes which will be fairly mild in case returns are low; and they may also, through superior knowledge and foresight, persuade governments to allow them easier treatment than they themselves if pressed would be prepared to accept.

As a result, the conventional means of taxing natural resource projects, with royalties, proportional company income taxes and other charges applied at rates that are negotiated in advance of investment, give governments that control the use of the resources an unnecessarily small share of the benefits of successful projects. On the other hand, arbitrary interference in the terms of access to natural resources in times of changing prices and changing perceptions of production costs has led to income losses through reduced investment.

This article has argued that expected government revenue from natural resource projects is likely to be increased by imposing instead a system under which tax is introduced and its rate increased when certain threshold internal rates of return have been realised (the Resource Rent Tax). Assessment under this system requires the accumulation at specified interest rates of all payments and receipts in respect of the establishment and operation of the project.

Two characteristics of the scheme are particularly noteworthy:

(1) For purposes of calculating the tax payable in any current year, net losses and outlays on investment in previous years may be accumulated at a specified "threshold interest rate" and offset against the net assessable income in the current year (in so far as they have not already been used in this way to offset income in a previous year). This provides opportunity for a "tax holiday", but one whose duration is inversely related to the historical profitability of the project.

(2) Separate taxes may be levied at more than one threshold interest rate: for example, a 50 % tax may be levied beyond the threshold of a 10 % interest rate, and a further 25 % tax beyond the level of a 20 % interest rate.

These features enable firms to avoid paying taxes in early years if they have high development expenses (which may be offset against the profits of early years), or if profits are unexpectedly low in early years. At the same time they enable the government to ensure that, if eventually profits are high, it may then cream off a high proportion of them in tax, without thereby having any great effect in discouraging investment on either new or existing projects.

The details of this scheme are explained through a numerical example set out in the appendix.

The net effect of the system is thus to reduce the risk of loss to the investor that is associated with a given expected tax yield and hence to raise the expected tax yield that is likely to be acceptable in advance to the investor.

Since the system also renders reasonable the adoption of a single system of taxation for each resource industry, it may be used to obviate the *ad hoc* negotiations over the taxation of individual projects in which governments may suffer from their relative ignorance of likely future costs and prices.

The process of accumulating at specified interest rates ensures that fluctuations in commodity prices and associated fluctuations in annual profits do not affect the internal rate of return at which Resource Rent Tax, and higher rates of Resource Rent Tax, become payable. In an era of great uncertainty about prices and costs, the taxation principles described in this paper may provide the resource-rich countries with an opportunity for more fruitful use of their endowments.

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APPENDIX: ASSESSING THE RESOURCE RENT TAX

This appendix is inserted to show the steps that need to be taken in actual calculation of the Resource Rent Tax.

The reader is referred to the definitions of "assessable receipts" and "deductible payments" and "net assessable receipts" (NAR) given in the body of the text. NAR in any year might be a positive or a negative quantity.

NAR may be expected to be negative over the first few years of a project's life which cover the period of initial investment. At the end of each year through the early life of the project, an accumulated value figure is calculated which represents the sum of all NAR figures up to and including that year, each raised by the interest rate of $x\%$ per year (the first threshold rate). When a year is reached at which the present value so calculated is positive, $a\%$ (say 50%) of that positive present value is taken in tax for that year.

In all subsequent years until a time is reached when the current year's NAR is once more negative, $a\%$ (say 50%) of the NAR of each year is taken as tax.

If in any subsequent year or consecutive years (years $n+1$, $n+2$, ..., $n+m$) NAR is negative, no tax is collected in any of these years, but in each year an accumulated value of all NARs from that of year $(n+1)$ is calculated with an $x\%$ interest rate, and this process continues until again a year is reached when the accumulated value is positive. In this year $a\%$ of this accumulated value is collected in tax. In subsequent years, while NAR is positive, $a\%$ of NAR is collected each year until again a year is reached at which NAR is negative, when once again no tax is collected and the sequence is repeated.

Precisely the same set of operations is performed in order to assess the additional tax that has to be paid when rates of return in excess of $y\%$ have been realised, except that $y\%$ is used as the discount rate, and the additional tax is assessed at $b\%$ (instead of $a\%$) of the relevant aggregate.

As explained in the text, the effect would be to tax at $a\%$ that part of profit from the project (net of company tax and royalties) which would cause the rate of return on funds to exceed $x\%$ but not to exceed $y\%$ and at

$(a+b)$ % that part of profit which would cause the rate of return to exceed y %. The exercise could be extended to tax at $(a+b+c)$ % that part of profit which would cause the rate of return to exceed z %. Table I is a hypothetical example.

TABLE I

Year (1)	Assess-able receipts (2)	Deduct-ible payments (3)	NAR, (2) − (3) (4)	Accumulated value of NAR of current year and previous series of years with negative current or accumulated value of NAR (10% interest) (5)	Tax on returns over 10% threshold at 50% rate of tax (6)	Accumulated value of NAR of current year and previous series of years with negative current or accumulated value of NAR (20% interest) (7)	Tax on returns over 20% threshold at 25% rate of tax (8)	Total tax, (6) + (8) (9)
1	—	100	− 100	− 100	—	− 100	—	—
2	—	300	− 300	− 410	—	− 420	—	—
3	50	100	− 50	− 501	—	− 554	—	—
4	200	50	150	− 401	—	− 515	—	—
5	200	50	150	− 291	—	− 468	—	—
6	200	50	150	− 170	—	− 412	—	—
7	200	50	150	− 37	—	− 344	—	—
8	200	50	150	109	54·5	− 263	—	54·5
9	200	50	150		75	− 166	—	75
10	200	50	150		75	− 49	—	75
11	200	250	− 50	− 50	—	− 109	—	—
12	200	50	150	95	47·5	19	4·75	52·25
13	200	50	150		75		37·5	112·5
14	200	50	150		75		37·5	112·5
15	200	50	150		75		37·5	112·5

c) Upgrading

Tom McCann commenced his presentation on upgrading by displaying and speaking to a series of viewgraphs that dealt with upgrading in a general way and addressed considerations of "Scale". His underlying theme was:

- One should upgrade at the mine site only if it is necessary, or if it is the cheapest from a location-considered standpoint.
- The advantages of scale tend to be overstated and often do not incorporate all of the relevant factors.

The following viewgraphs were used by Tom:

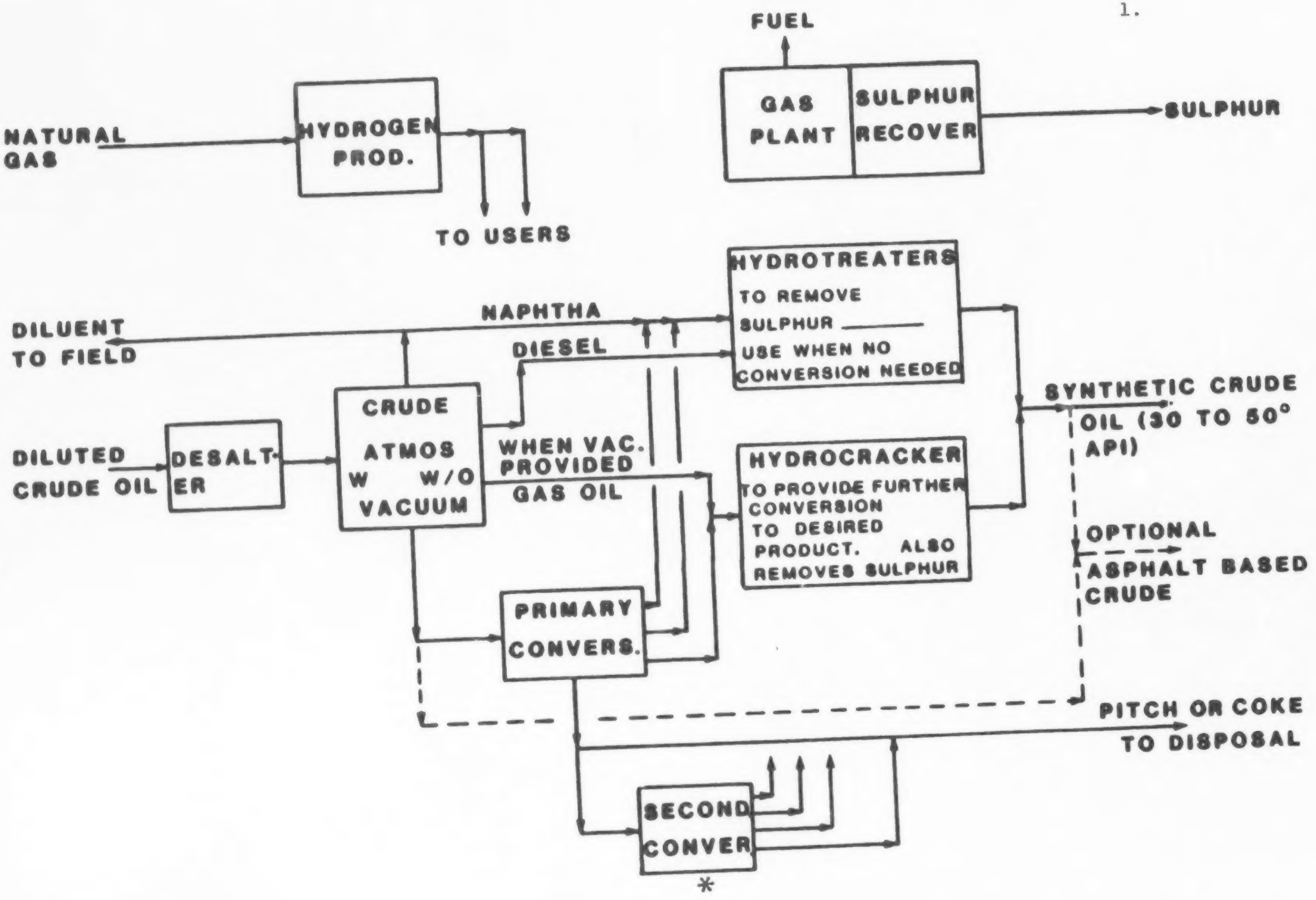
1. Simplified Schematic of Small Upgrader
2. Table 5.1 - Operating Cost Summary
3. Capital Cost Exponents - Fig. 7.1
4. Generalized Cost - Capacity Curves - Fig. 7.2
5. Plains Upgrader
   Typical Decision to Onstream Time - Fig. 6.1
6. Cost Exponent
   Typical of Low Pressure Conversion Upgraders - Fig. 7.3
7. Cost Exponent - Typical of High Pressure Conversion Upgraders - Fig. 7.4

In speaking to the above viewgraphs and in responding to questions, it was recognized that the Cost Exponent Curves should not be used without thorough analysis as to their applicability to a given set of circumstances. Time from project inception to startup is an important factor when assessing scale considerations.

It was pointed out that because of the way integrated plants are treated tax-wise - Syncrude project economics dictated that the upgrader be located at the mine site as opposed to being remotely located. Mr. Hyndman distributed a handout entitled ".....The desirable features of a tax and royalty regime for the Oil Sands are as follows: (see Page 47):

Tom continued his viewgraph presentation, explaining that process underlined by broken lines were experimental and those underlined with a solid line were commercially proven.

1.


FUEL
NATURAL GAS
HYDROGEN PROD.
TO USERS
GAS PLANT
SULPHUR RECOVER
SULPHUR
HYDROTREATERS
TO REMOVE SULPHUR
USE WHEN NO CONVERSION NEEDED
NAPHTHA
DILUENT TO FIELD
DIESEL
DILUTED CRUDE OIL
DESALTER
CRUDE
ATMOS
W W/O
VACUUM
WHEN VAC. PROVIDED
GAS OIL
HYDROCRACKER
TO PROVIDE FURTHER CONVERSION TO DESIRED PRODUCT. ALSO REMOVES SULPHUR
SYNTHETIC CRUDE OIL (30 TO 50° API)
OPTIONAL
ASPHALT BASED CRUDE
PRIMARY CONVERS.
PITCH OR COKE TO DISPOSAL
SECOND CONVER
*

*Applicable to H-Oil/LCFining route only.

SIMPLIFIED SCHEMATIC
OF
SMALL UPGRADER

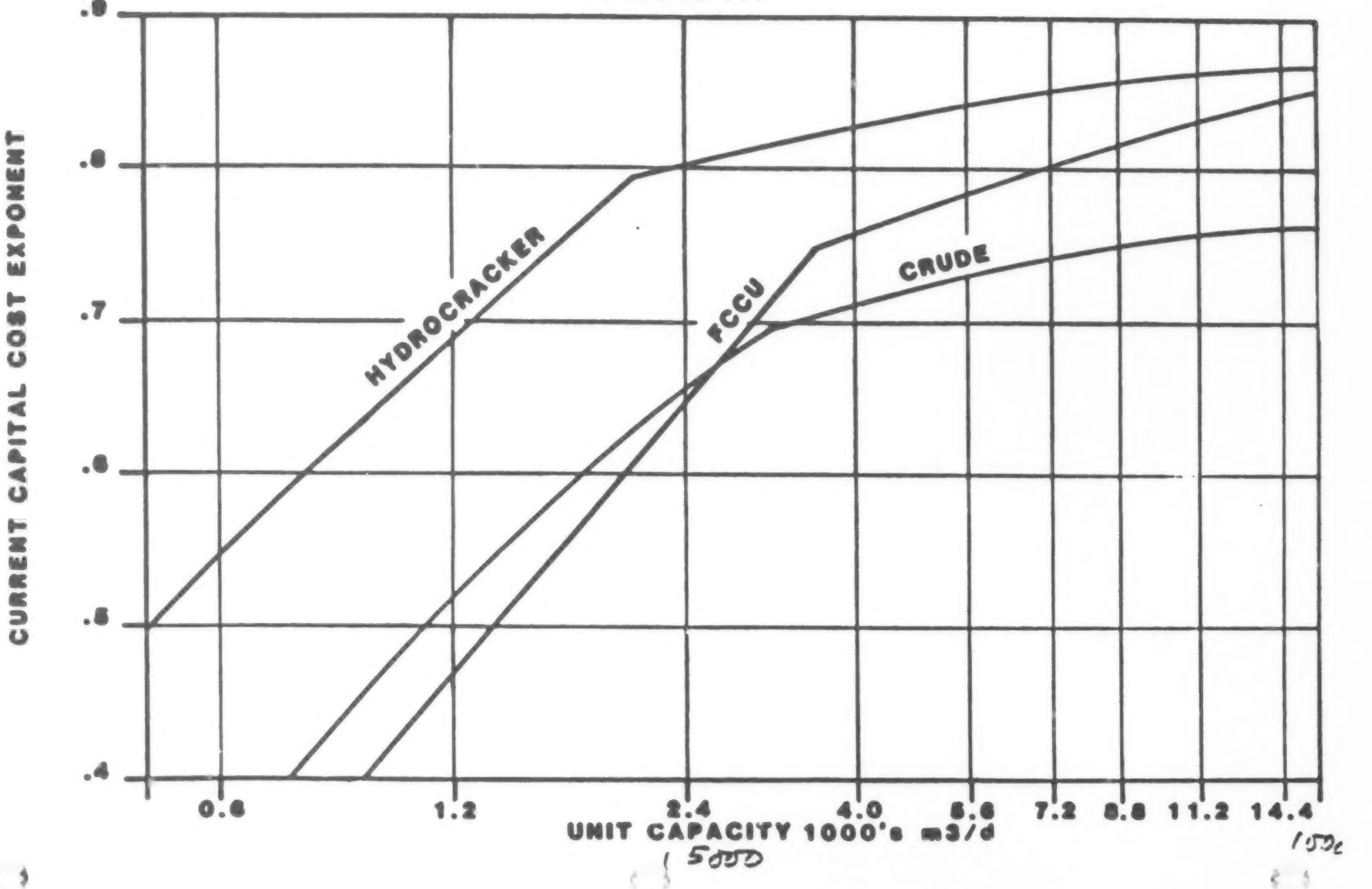
TABLE 5.1

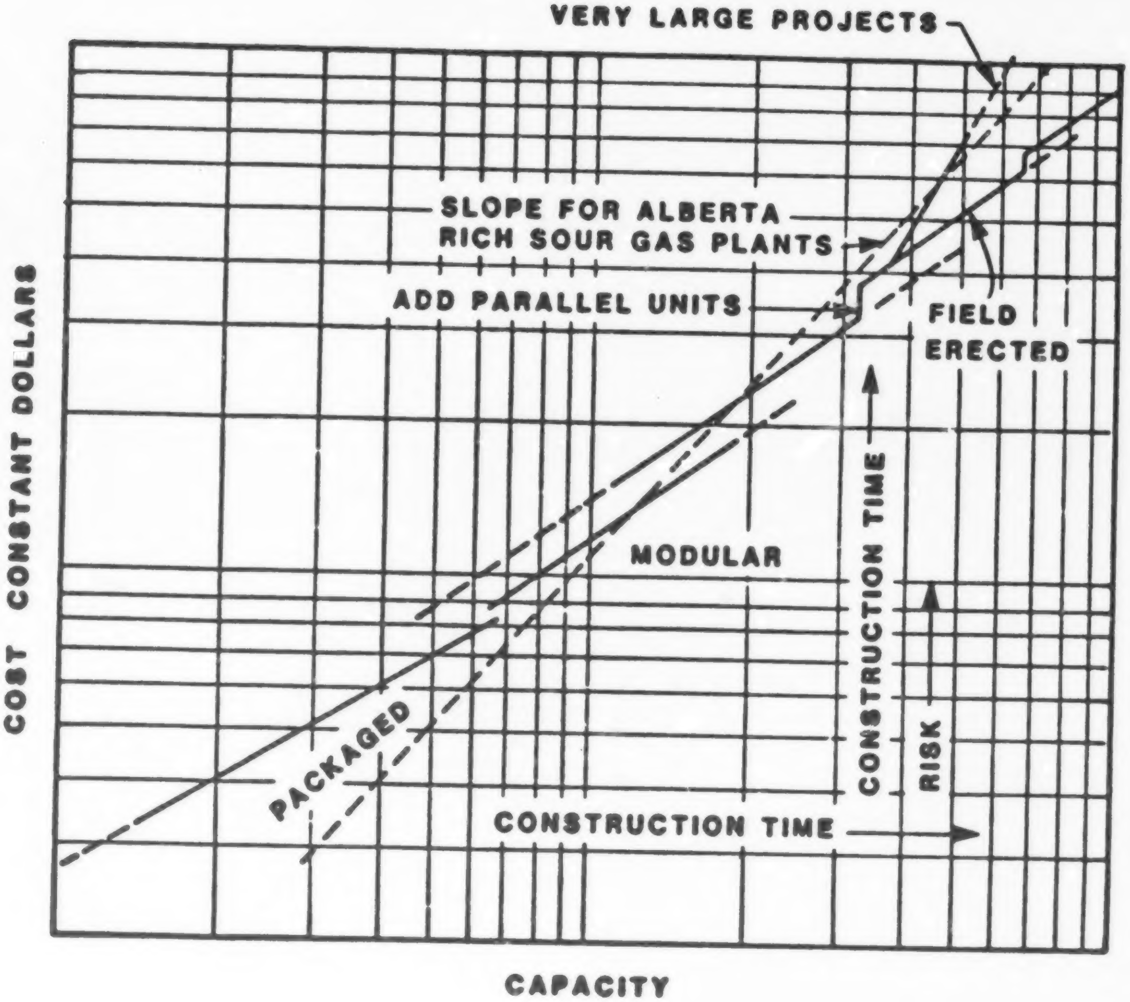
OPERATING COST SUMMARY

Cost Sector	Range (as % of overall operating costs)	Scale Exponent
Natural Gas	15 to 45	0.95 to 1.0
Electricity	0 to 6	0.95 to 1.0
Catalyst and Chemicals	7 to 12	1.0
Maintenance	25 to 45	1.0
Supervision & Other Labour	3 to 7	0.5
Miscellaneous Costs	2 to 6	0.50 to 1.0
Insurance and Taxes	8 to 12	0.95 to 1.0
Overall	\$20 to \$45/m^3 (1982)	0.95 to 0.98

CAPITAL COST EXPONENTS

FIGURE 7.1





NOTE: NO INFLATION OR INTEREST COSTS INCLUDED

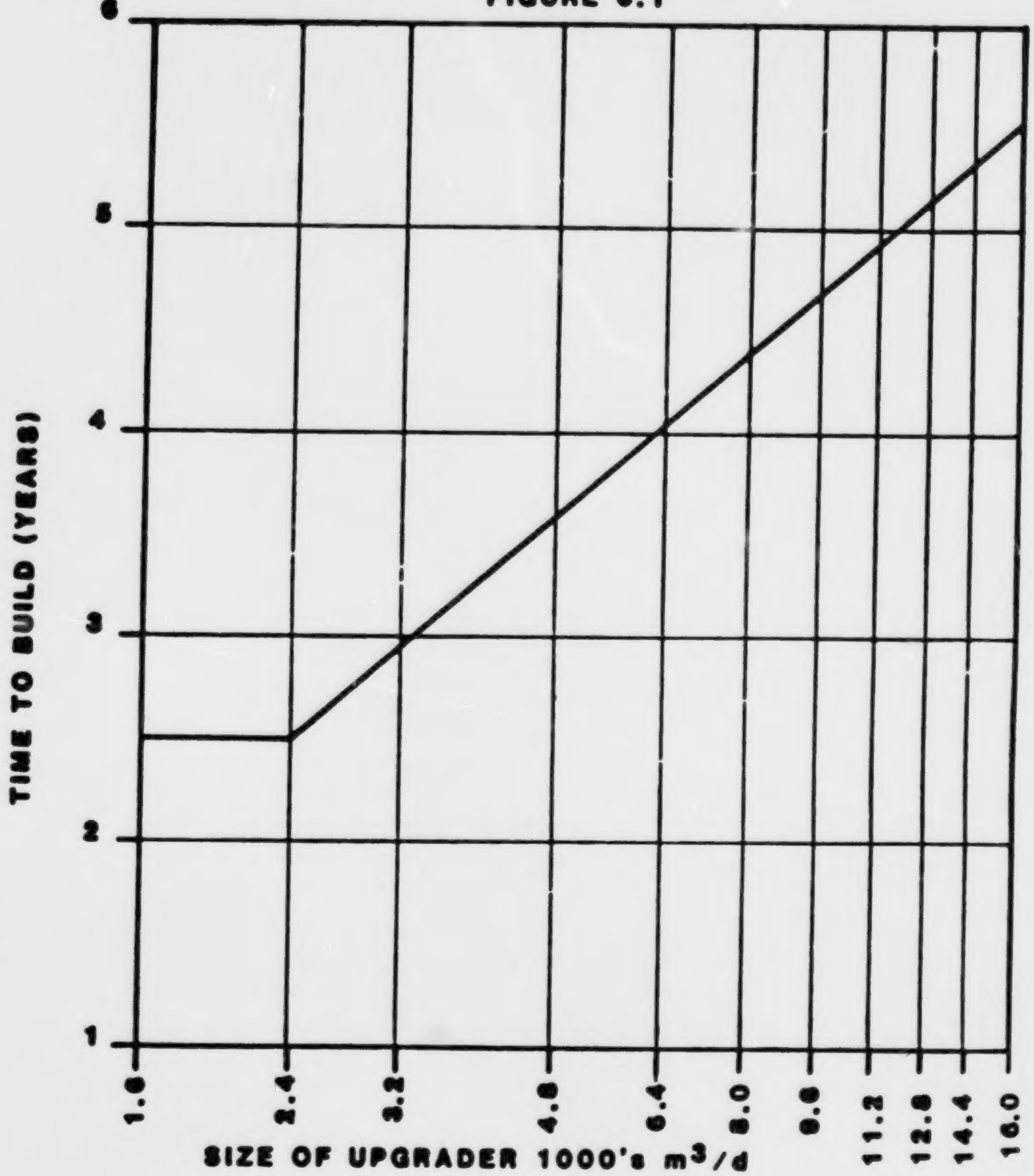
GENERALIZED COST-CAPACITY CURVES

FIGURE 7.2

PLAINS UPGRADER

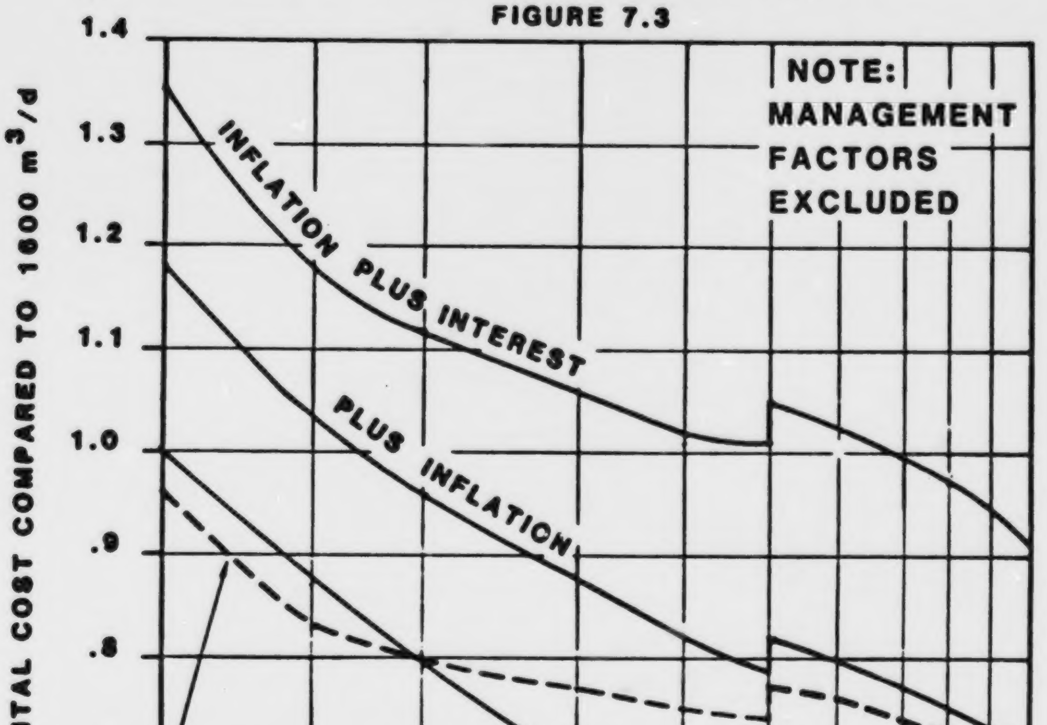
TYPICAL DECISION-TO-ONSTREAM TIME

FIGURE 6.1



COST EXPONENT TYPICAL OF LOW PRESSURE CONVERSION UPGRADERS

FIGURE 7.3

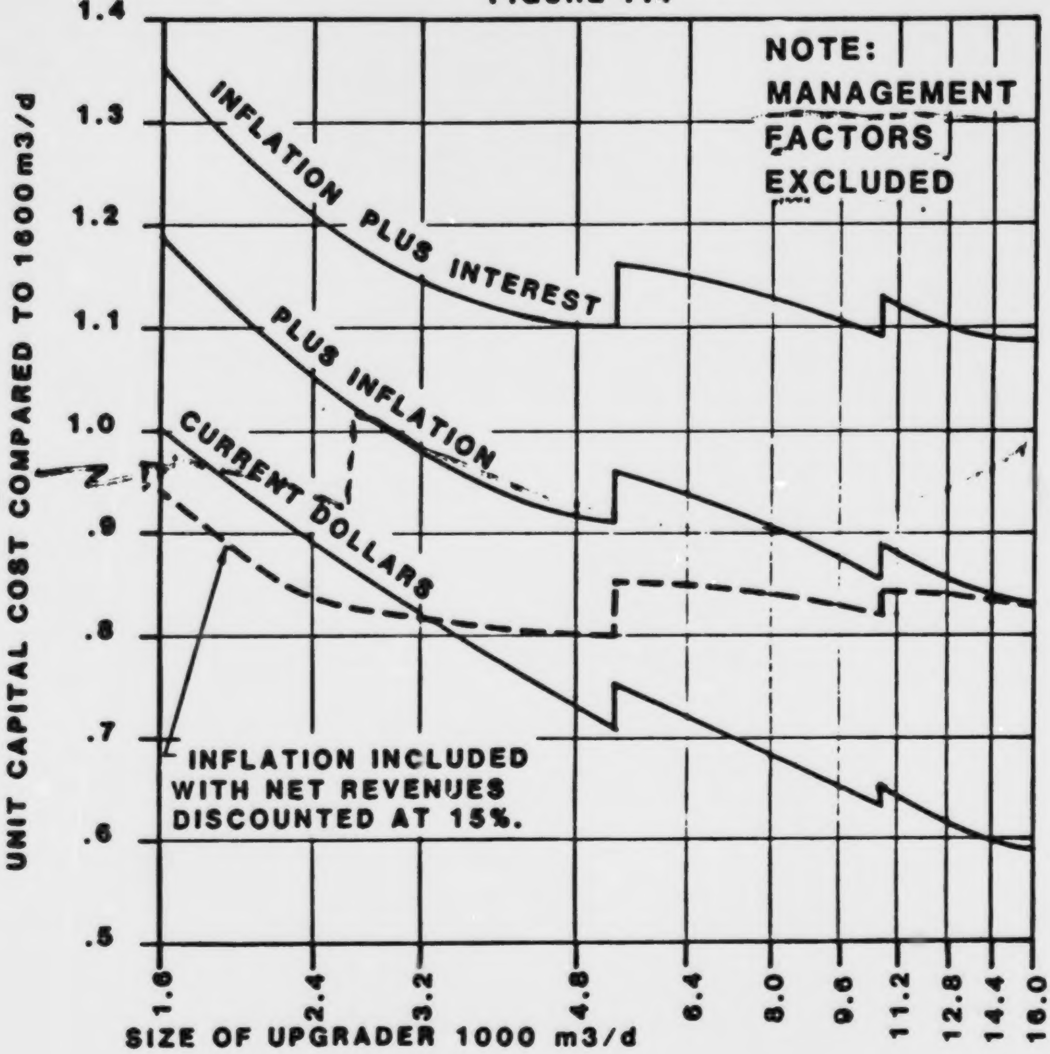


7.

0.7 Exponent

COST EXPONENT TYPICAL OF HIGH PRESSURE CONVERSION UPGRADERS

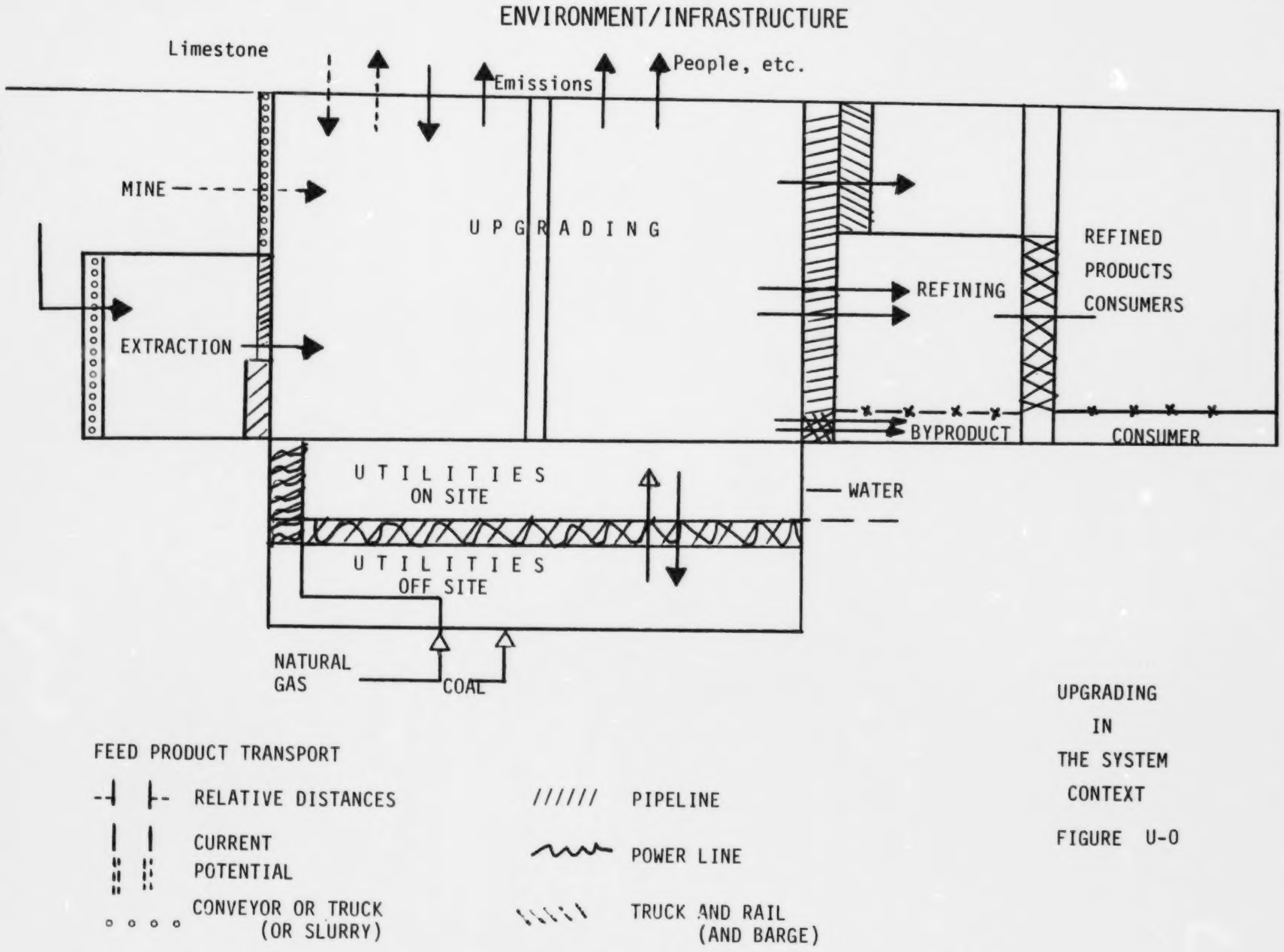
FIGURE 7.4



2 on
UNION 2

The desirable features of a tax and royalty regime for the oil sands are as follows:

- The regime should be compatible with a broad range of petroleum prices. Therefore, the rates should be low when margins are slim and should increase to capture a share of windfall profits.
- Taxes and Royalty payments should come into play after initial capital and investment costs have been substantially recovered.
- The structure should be biased in favor of capital reinvestment to encourage the maintenance of a modern operation and productivity improvements. Tax and royalty payments should be calculated after annual capital requirements are met.
- Federal/Provincial revenue splits should be predetermined. Tax and Royalty policy should be co-ordinated.
- Increased efficiency should not be taxed away. To do so would be to discourage R & D and investment in efficiency. This would also indicate that the same formula should apply to all operators, regardless of size, age or location (i.e. existing operations should be offered the same arrangement).
- The formula should be simple, easy to understand, and not require a large effort on the part of industry or government to administer.
- The regime should be put in place for an extended period to allow stability of development.


ENVIRONMENT/INFRASTRUCTURE
Limestone
Emissions
People, etc.
MINE
EXTRACTION
U P G R A D I N G
REFINING
REFINED
PRODUCTS
CONSUMERS
BYPRODUCT
CONSUMER
U T I L I T I E S
ON SITE
U T I L I T I E S
OFF SITE
WATER
NATURAL
GAS
COAL
FEED PRODUCT TRANSPORT
RELATIVE DISTANCES
CURRENT
POTENTIAL
CONVEYOR OR TRUCK
(OR SLURRY)
////// PIPELINE
POWER LINE
TRUCK AND RAIL
(AND BARGE)

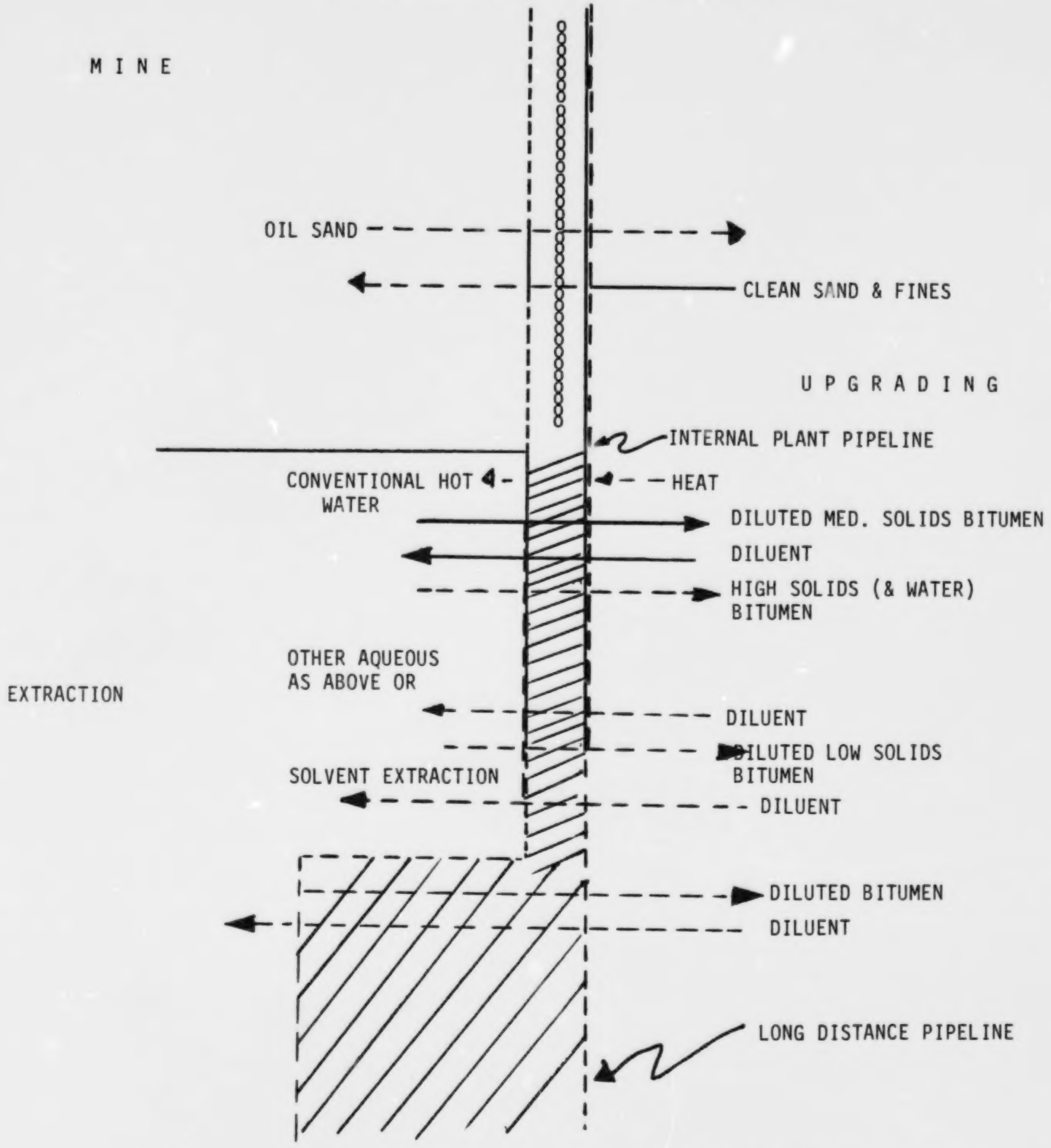
UPGRADING
IN
THE SYSTEM
CONTEXT

FIGURE U-0

8.

UPGRADING IS THE MEANS USED TO CONVERT BITUMEN TO FORMS USEABLE IN THE ECONOMY - EITHER DIRECTLY OR VIA OTHER EXISTING OR NEW CONVENTIONAL FACILITIES.

MINE/EXTRACTION UPGRADING INTERFACES

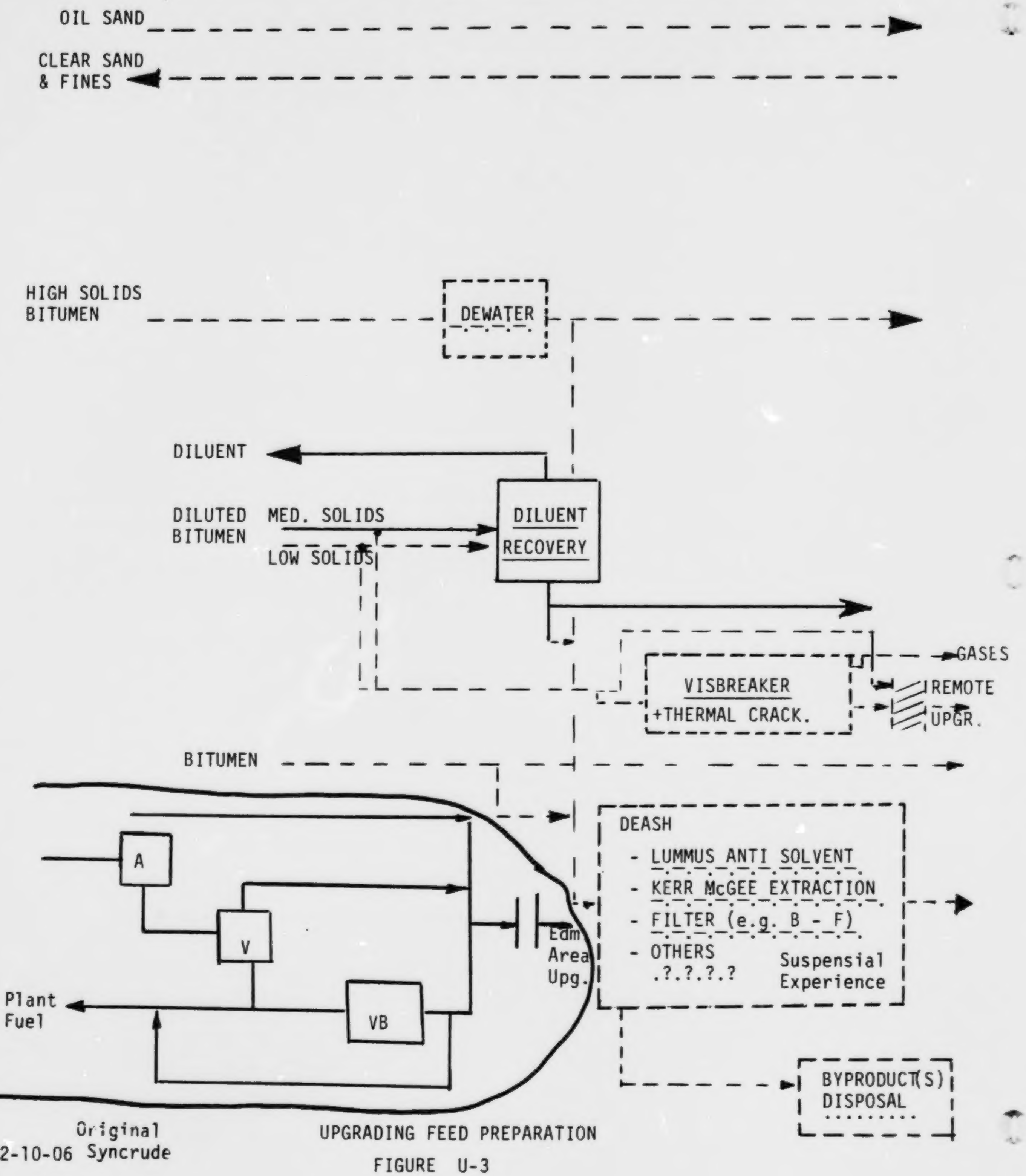

MINE
OIL SAND
CLEAN SAND & FINES
UPGRADING
INTERNAL PLANT PIPELINE
CONVENTIONAL HOT WATER
HEAT
DILUTED MED. SOLIDS BITUMEN
DILUENT
HIGH SOLIDS (& WATER) BITUMEN
OTHER AQUEOUS AS ABOVE OR
EXTRACTION
DILUENT
DILUTED LOW SOLIDS BITUMEN
SOLVENT EXTRACTION
DILUENT
DILUTED BITUMEN
DILUENT
LONG DISTANCE PIPELINE

MINE/UPGRADING/EXTRACTION
INTERFACES

FIGURE U-2

FEED PREPARATION

10.

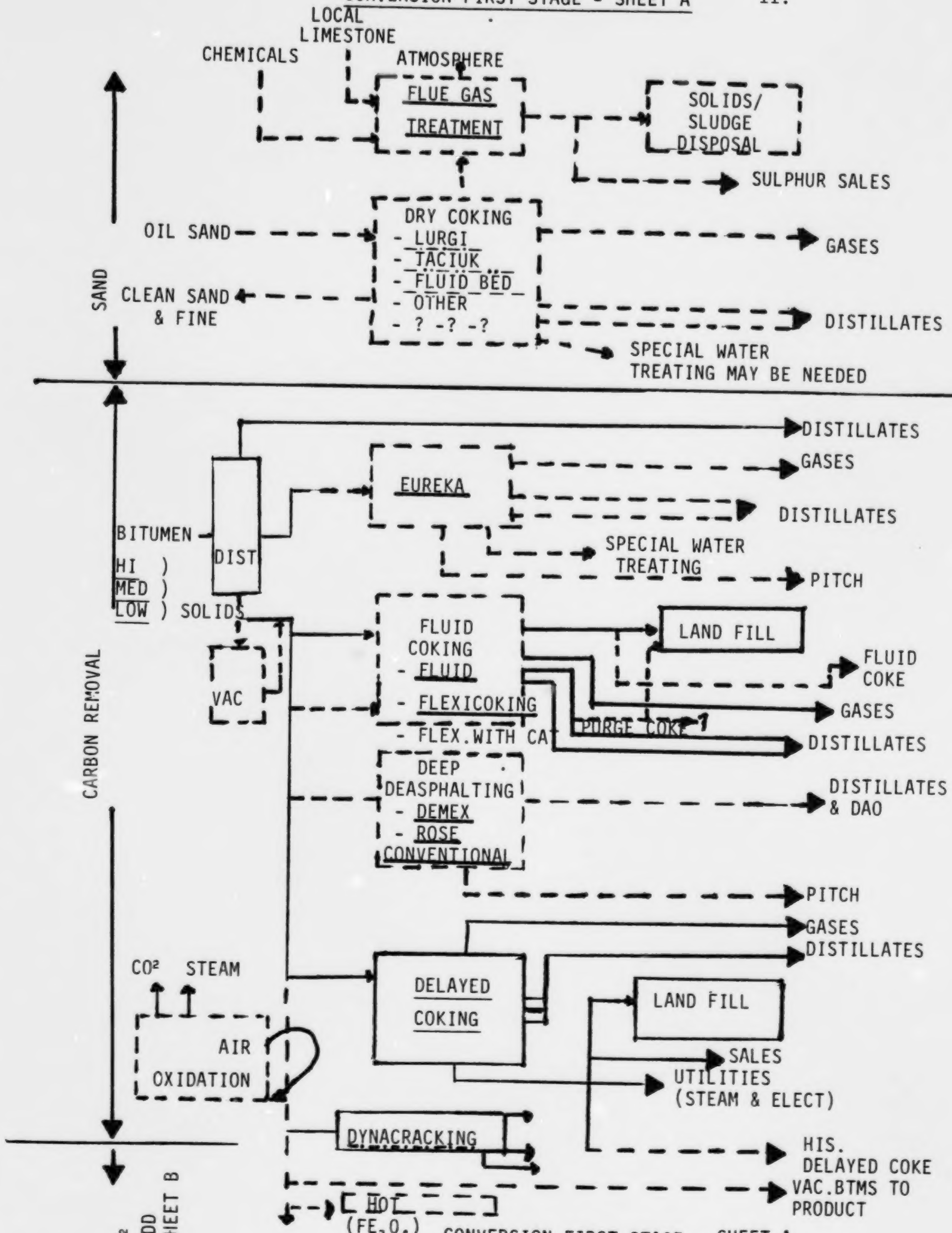

OIL SAND
CLEAR SAND & FINES
HIGH SOLIDS BITUMEN
DEWATER
DILUENT
DILUTED BITUMEN
MED. SOLIDS
LOW SOLIDS
DILUENT RECOVERY
GASES
VISBREAKER +THERMAL CRACK.
REMOTE UPGR.
BITUMEN
A
V
VB
Plant Fuel
Edm Area Upg.
DEASH
- LUMMUS ANTI SOLVENT
- KERR McGEE EXTRACTION
- FILTER (e.g. B - F)
- OTHERS .?.?.?.?
Suspensial Experience
BYPRODUCT(S) DISPOSAL
Original Syncrude

82-10-06

UPGRADING FEED PREPARATION

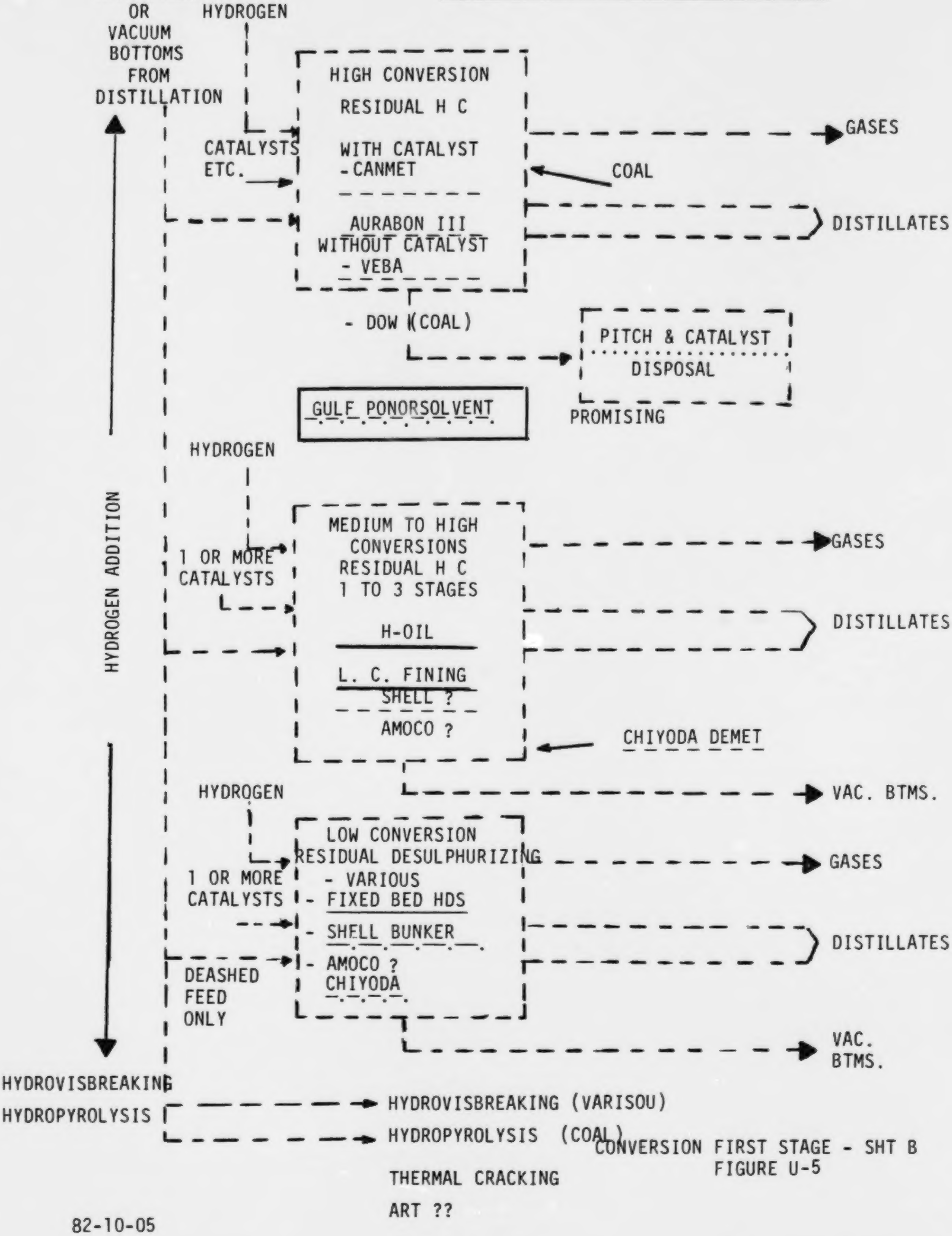
FIGURE U-3

CONVERSION FIRST STAGE - SHEET A


LOCAL
LIMESTONE
CHEMICALS
ATMOSPHERE
FLUE GAS
TREATMENT
SOLIDS/
SLUDGE
DISPOSAL
SULPHUR SALES
OIL SAND
DRY COKING
- LURGI
- TACIUK
- FLUID BED
- OTHER
- ? -? -?
GASES
SAND
CLEAN SAND
& FINE
DISTILLATES
SPECIAL WATER
TREATING MAY BE NEEDED
DISTILLATES
GASES
EUREKA
DISTILLATES
BITUMEN
DIST
HI)
MED)
LOW) SOLIDS
SPECIAL WATER
TREATING
PITCH
VAC
FLUID
COKING
- FLUID
- FLEXICOKING
- FLEX.WITH CAT
LAND FILL
FLUID
COKE
GASES
PURGE COKE
DISTILLATES
CARBON REMOVAL
DEEP
DEASPHALTING
- DEMEX
- ROSE
CONVENTIONAL
DISTILLATES
& DAO
PITCH
GASES
DISTILLATES
CO²
STEAM
DELAYED
COKING
LAND FILL
AIR
OXIDATION
SALES
UTILITIES
(STEAM & ELECT)
DYNACRACKING
HIS.
DELAYED COKE
VAC.BTMS TO
PRODUCT
HOT
(FE₃O₄)
H₂
ADD
SHEET B

CONVERSION FIRST STAGE - SHEET A
FIGURE U-4

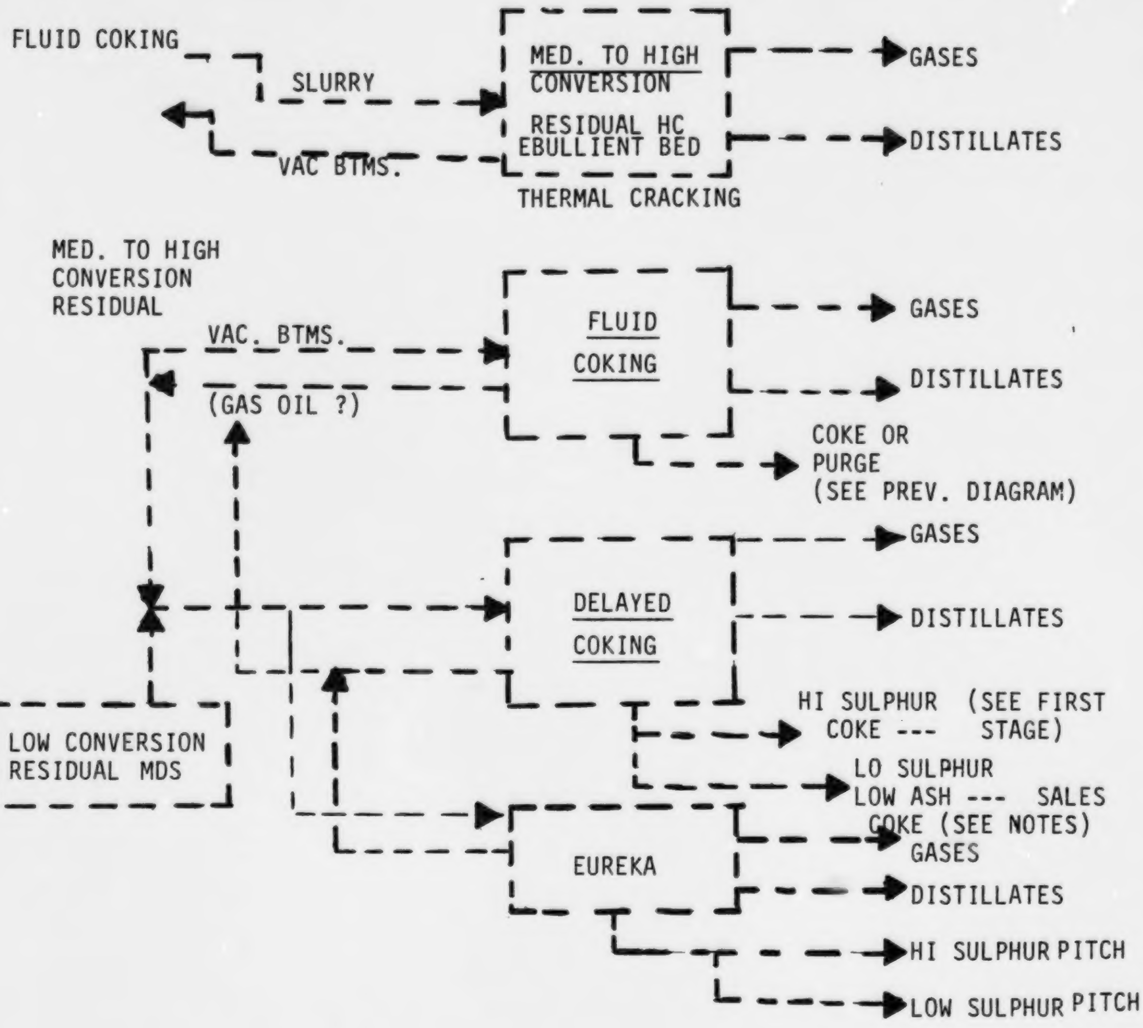
CONVERSION FIRST - STAGE - SHEET B


ATMOSPHERIC OR VACUUM BOTTOMS FROM DISTILLATION
HYDROGEN
HIGH CONVERSION
RESIDUAL H C
WITH CATALYST
- CANMET
CATALYSTS ETC.
AURABON III
WITHOUT CATALYST
- VEBA
- DOW (COAL)
COAL
GASES
DISTILLATES
PITCH & CATALYST
DISPOSAL
PROMISING
GULF PONORSOLVENT
HYDROGEN ADDITION
HYDROGEN
MEDIUM TO HIGH CONVERSIONS
RESIDUAL H C
1 TO 3 STAGES
1 OR MORE CATALYSTS
H-OIL
L. C. FINING
SHELL ?
AMOCO ?
CHIYODA DEMET
GASES
DISTILLATES
VAC. BTMS.
HYDROGEN
LOW CONVERSION
RESIDUAL DESULPHURIZING
- VARIOUS
- FIXED BED HDS
- SHELL BUNKER
- AMOCO ?
CHIYODA
1 OR MORE CATALYSTS
DEASHED FEED ONLY
GASES
DISTILLATES
VAC. BTMS.
HYDROVISBREAKING
HYDROPYROLYSIS
HYDROVISBREAKING (VARISOU)
HYDROPYROLYSIS (COAL)
THERMAL CRACKING
ART ??

CONVERSION FIRST STAGE - SHT B
FIGURE U-5

82-10-05

CONVERSION SECOND - STAGE


FLUID COKING
SLURRY
VAC BTMS.
MED. TO HIGH CONVERSION
RESIDUAL HC
EBULLIENT BED
THERMAL CRACKING
GASES
DISTILLATES
MED. TO HIGH CONVERSION RESIDUAL
VAC. BTMS.
(GAS OIL ?)
FLUID COKING
GASES
DISTILLATES
COKE OR PURGE (SEE PREV. DIAGRAM)
DELAYED COKING
GASES
DISTILLATES
HI SULPHUR COKE --- (SEE FIRST STAGE)
LO SULPHUR LOW ASH COKE --- SALES (SEE NOTES)
LOW CONVERSION RESIDUAL MDS
EUREKA
GASES
DISTILLATES
HI SULPHUR PITCH
LOW SULPHUR PITCH

NOTE re Low Sulphur Coke & Pitch
A deashed feed to a medium to high conversion residual hydrocracker will be essential and the conversion level may have to be kept down to insure a suitable coke. The degree of desulphurization and demetallization of the coker feed must be such as to permit specification coke quantities to be met.

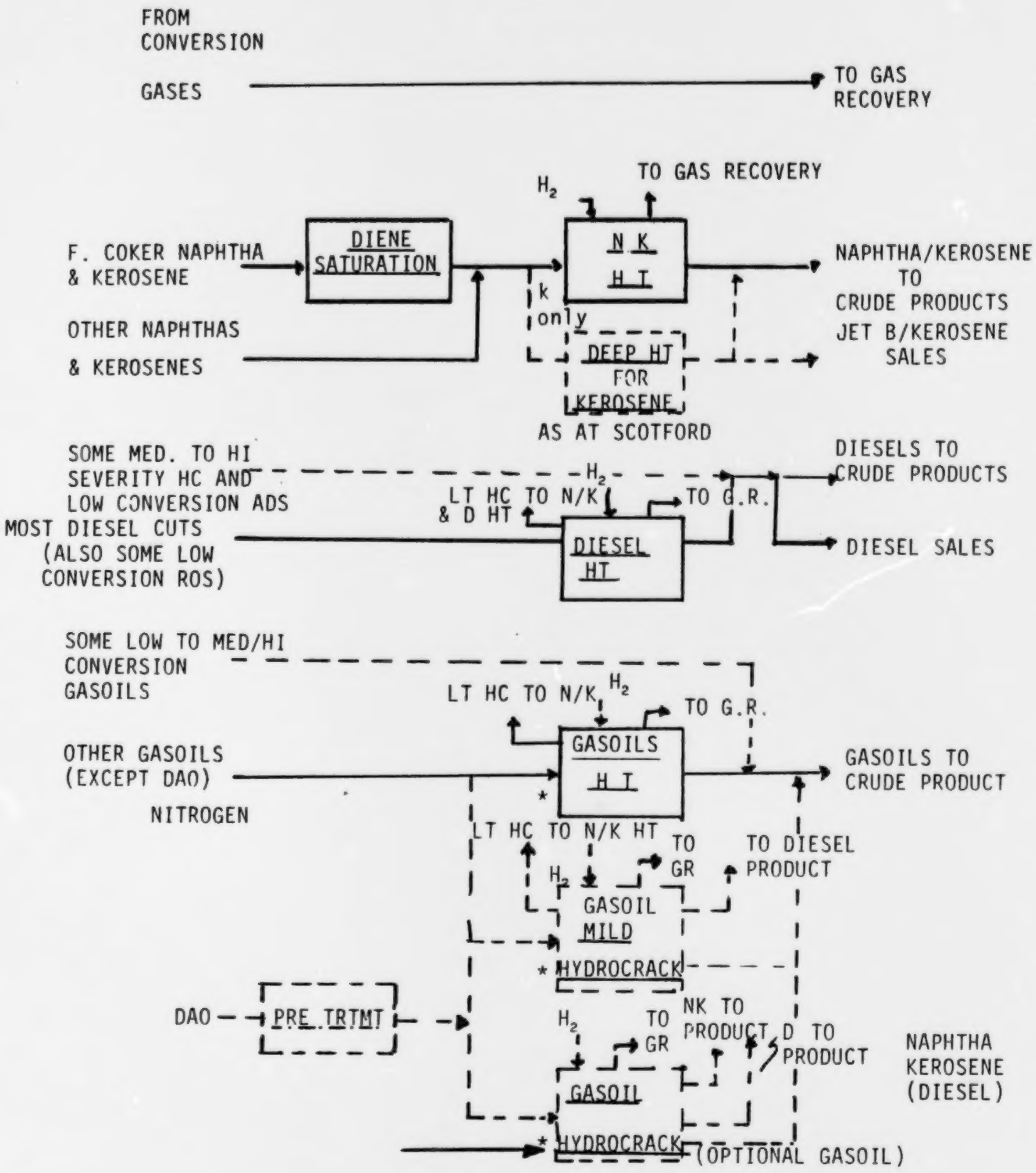
SEE ALSO

CONVERSION SECOND STAGE

FIGURE U-6

82-10-06

HYDROGENATION


FROM
CONVERSION
GASES
TO GAS RECOVERY
H_2
TO GAS RECOVERY
F. COKER NAPHTHA & KEROSENE
DIENE SATURATION
N K H T
NAPHTHA/KEROSENE TO CRUDE PRODUCTS
k only
OTHER NAPHTHAS & KEROSENES
DEEP HT FOR KEROSENE
JET B/KEROSENE SALES
AS AT SCOTFORD
SOME MED. TO HI SEVERITY HC AND LOW CONVERSION ADS
H_2
DIESELS TO CRUDE PRODUCTS
LT HC TO N/K & D HT
TO G.R.
MOST DIESEL CUTS (ALSO SOME LOW CONVERSION ROS)
DIESEL HT
DIESEL SALES
SOME LOW TO MED/HI CONVERSION GASOILS
LT HC TO N/K
H_2
TO G.R.
OTHER GASOILS (EXCEPT DAO)
GASOILS H T
GASOILS TO CRUDE PRODUCT
*
NITROGEN
LT HC TO N/K HT
TO GR
TO DIESEL PRODUCT
H_2
GASOIL MILD HYDROCRACK
*
DAO
PRE TRTMT
H_2
TO GR
NK TO PRODUCT
D TO PRODUCT
NAPHTHA KEROSENE (DIESEL)
GASOIL HYDROCRACK
*
(OPTIONAL GASOIL)

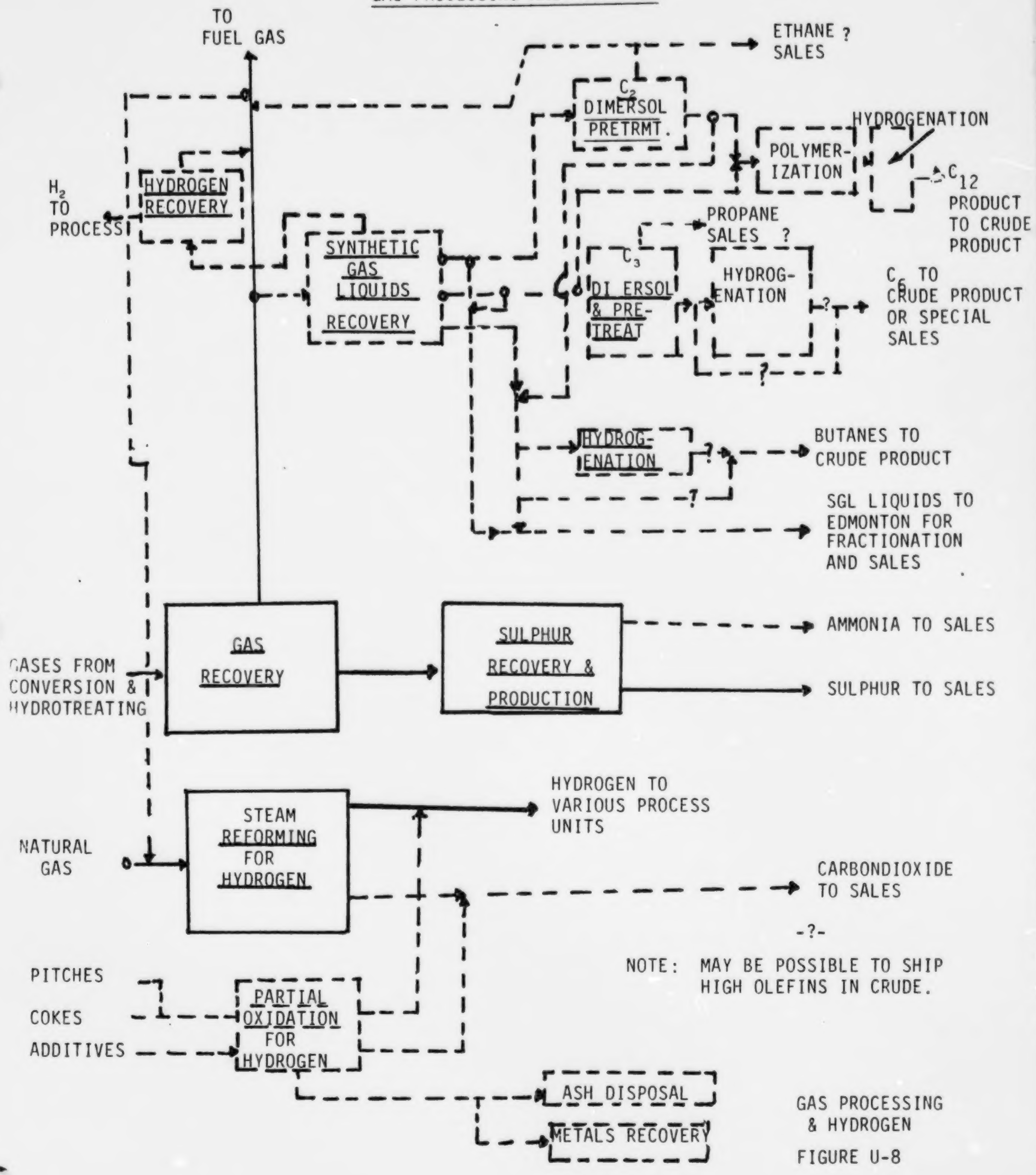
* NOTE: WITH ALL THE HYDROGEN CONVERSION PROCESSES SHOWN, IT IS POSSIBLE TO PUT THESE STEPS INTO A COMBINED UNIT OPERATING IN SERIES WITH THE CONVERSION REACTORS TO SAVE ON HIGH PRESSURE EQUIPMENT AND TO ENHANCE HYDROGENATION PROCESSES BUT SUCH AN APPROACH MUST BE CONSIDERED AS A NOW DEVELOPMENT.

E.G. VEBAS KAMBI-KAMMER PROCESS

HYDROGENATION - FIGURE U-7

82-10-05

GAS PROCESSING AND HYDROGEN


TO FUEL GAS
ETHANE ? SALES
C_2 DIMERSOL PRETRMT.
HYDROGENATION
POLYMER-IZATION
C_{12} PRODUCT TO CRUDE PRODUCT
H_2 TO PROCESS
HYDROGEN RECOVERY
SYNTHETIC GAS LIQUIDS RECOVERY
PROPANE SALES ?
C_3 DIMERSOL & PRE-TREAT
HYDROG-ENATION
C_6 TO CRUDE PRODUCT OR SPECIAL SALES
?
HYDROG-ENATION
BUTANES TO CRUDE PRODUCT
SGL LIQUIDS TO EDMONTON FOR FRACTIONATION AND SALES
GASES FROM CONVERSION & HYDROTREATING
GAS RECOVERY
SULPHUR RECOVERY & PRODUCTION
AMMONIA TO SALES
SULPHUR TO SALES
NATURAL GAS
STEAM REFORMING FOR HYDROGEN
HYDROGEN TO VARIOUS PROCESS UNITS
CARBONDIOXIDE TO SALES
-?-
PITCHES
COKES
ADDITIVES
PARTIAL OXIDATION FOR HYDROGEN
ASH DISPOSAL
METALS RECOVERY

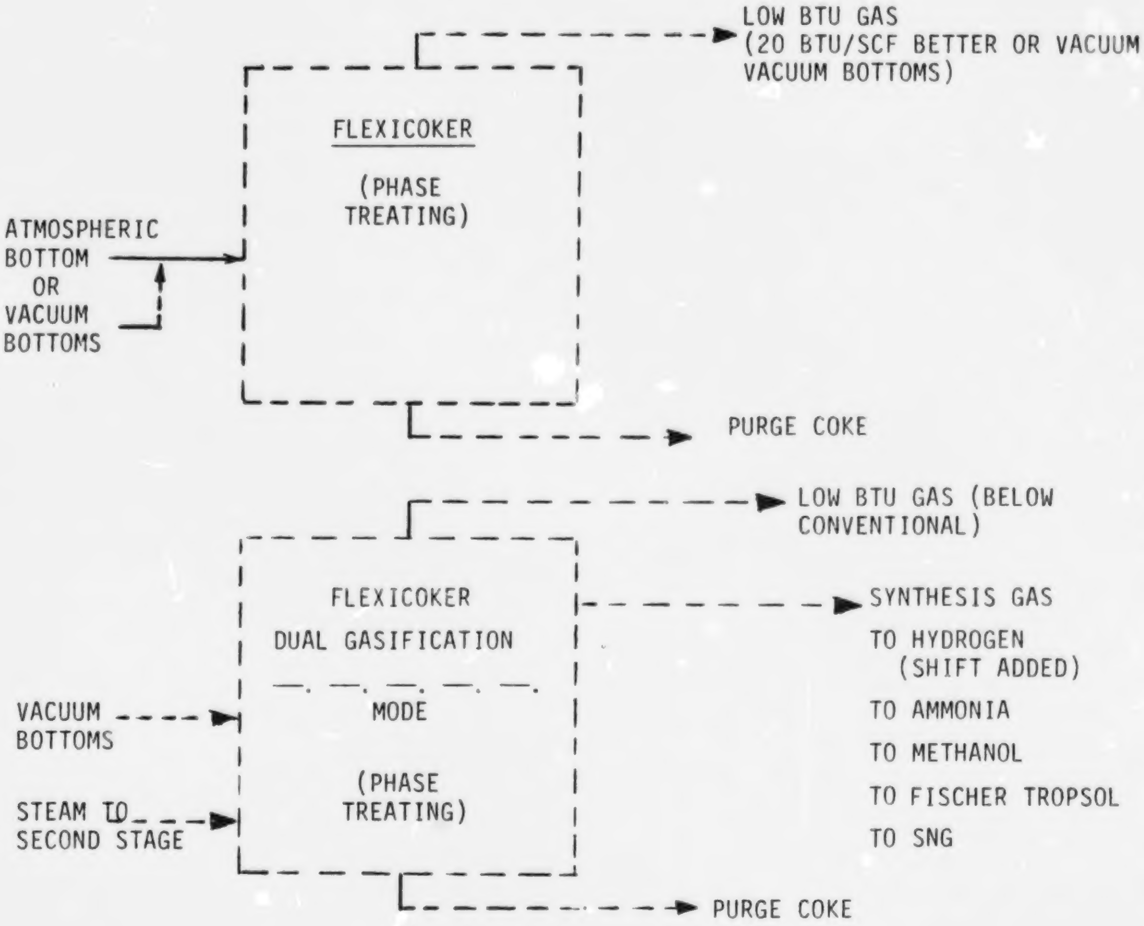
NOTE: MAY BE POSSIBLE TO SHIP HIGH OLEFINS IN CRUDE.

GAS PROCESSING & HYDROGEN

FIGURE U-8

82-10-06

- FLUID COKING GENERALLY - HIGHER YIELD THROUGH PROCESS REVISIONS
- FLUID COKING + H-OIL - ACTIVE DEVELOPMENT WORK
- FLUID COKING AND CATALYST - IN DEVELOPMENT - APPRECIABLE ENHANCED YIELDS
- FLUID COKING FOR OLEFINS - LOWER LIQUID YIELDS - HIGHER ETHYLENE, ETC.


LOW BTU GAS
(20 BTU/SCF BETTER OR VACUUM
VACUUM BOTTOMS)
FLEXICOKER
(PHASE
TREATING)
ATMOSPHERIC
BOTTOM
OR
VACUUM
BOTTOMS
PURGE COKE
LOW BTU GAS (BELOW
CONVENTIONAL)
FLEXICOKER
DUAL GASIFICATION
MODE
(PHASE
TREATING)
SYNTHESIS GAS
TO HYDROGEN
(SHIFT ADDED)
TO AMMONIA
TO METHANOL
TO FISCHER TROPSOL
TO SNG
VACUUM
BOTTOMS
STEAM TO
SECOND STAGE
PURGE COKE

NOTE:
- THERE APPEARS TO BE FURTHER POSSIBILITIES IN THE DUAL MODE GAS TO INCREASE SYNTHESIS GAS AND/OR IMPROVE LOW BTU GAS QUALITY.
- ADD LIME TO COKER FEED TO INCREASE YIELD AND TO HOLD AS SULFATE WHEN COKE BURNED (ARC).

COKING DEVELOPMENT
FIGURE U-11

COKE/PITCH DERIVATIVES

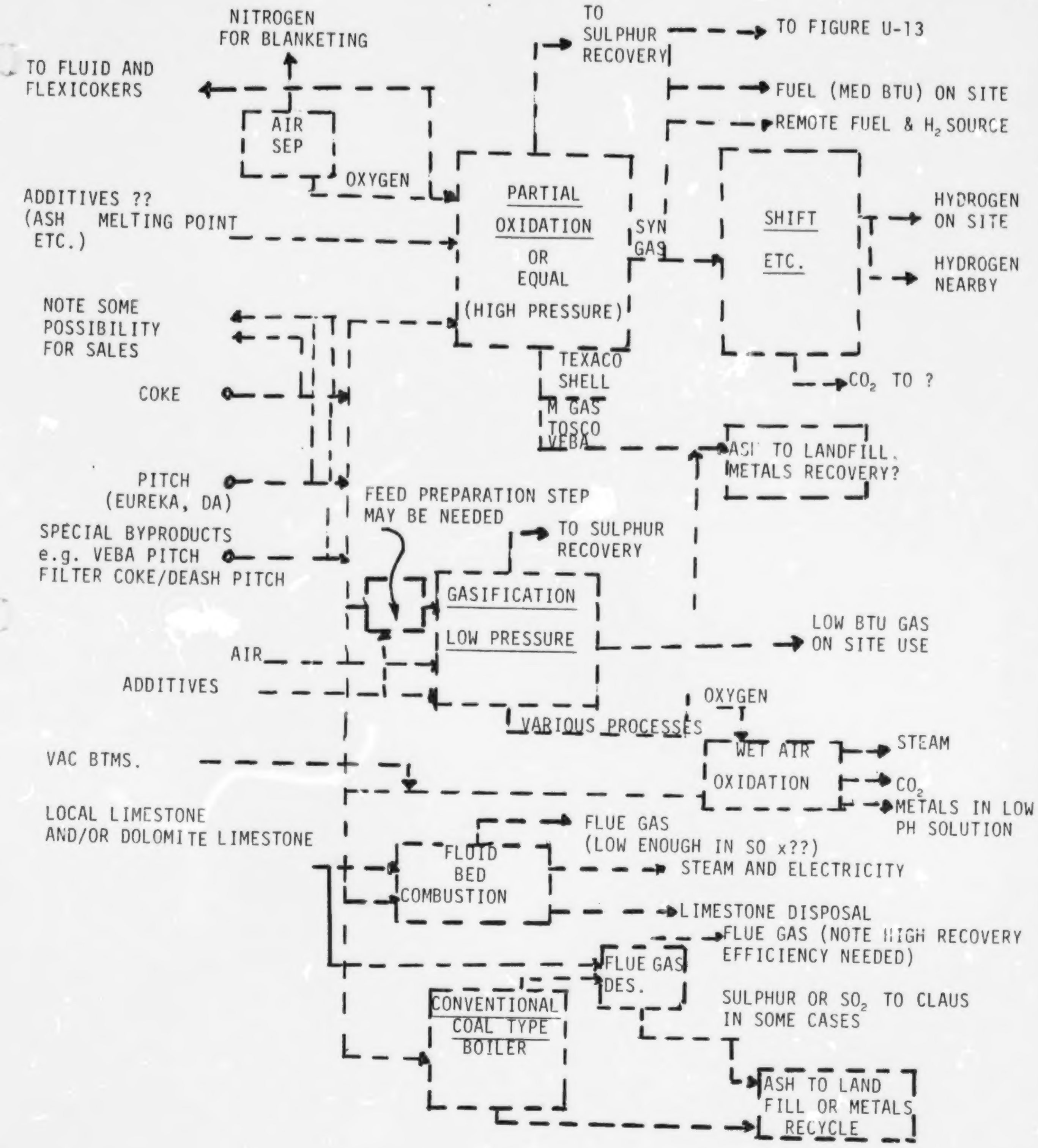

NITROGEN FOR BLANKETING
TO FLUID AND FLEXICOKERS
AIR SEP
OXYGEN
TO SULPHUR RECOVERY
TO FIGURE U-13
FUEL (MED BTU) ON SITE
REMOTE FUEL & H_2 SOURCE
ADDITIVES ?? (ASH MELTING POINT ETC.)
PARTIAL OXIDATION OR EQUAL (HIGH PRESSURE)
SYN GAS
SHIFT ETC.
HYDROGEN ON SITE
HYDROGEN NEARBY
NOTE SOME POSSIBILITY FOR SALES
TEXACO
SHELL
M GAS
TOSCO
VEBA
CO_2 TO ?
COKE
ASH TO LANDFILL. METALS RECOVERY?
PITCH (EUREKA, DA)
FEED PREPARATION STEP MAY BE NEEDED
SPECIAL BYPRODUCTS e.g. VEBA PITCH FILTER COKE/DEASH PITCH
TO SULPHUR RECOVERY
GASIFICATION LOW PRESSURE
LOW BTU GAS ON SITE USE
AIR
ADDITIVES
VARIOUS PROCESSES
OXYGEN
WET AIR OXIDATION
STEAM
CO_2
METALS IN LOW PH SOLUTION
VAC BTMS.
LOCAL LIMESTONE AND/OR DOLOMITE LIMESTONE
FLUE GAS (LOW ENOUGH IN SO x??)
FLUID BED COMBUSTION
STEAM AND ELECTRICITY
LIMESTONE DISPOSAL
FLUE GAS (NOTE HIGH RECOVERY EFFICIENCY NEEDED)
FLUE GAS DES.
SULPHUR OR SO_2 TO CLAUS IN SOME CASES
CONVENTIONAL COAL TYPE BOILER
ASH TO LAND FILL OR METALS RECYCLE

FIGURE U-12

SYNTHETIC CRUDE QUALITY

GENERALLY OVERALL SUNCOR WITH LESS GAS OIL AND MORE GOOD DIESEL

- BETTER KEROSENE IN SOME CASES NEEDED FOR JET FUEL
- MAY BE SCREAMS ABOUT MORE BUTANE UNLESS PRICE REDUCED

SOME TAILORING POSSIBLE FOR INDIVIDUAL REFINERIES

- E.G., ASPHALT WITH PREMIUM DISTILLATES IN SUMMER AT SOME REFINERIES

PETROMONT AND PETROSAR ABLE TO USE SYNTHETIC CONDENSATE TYPE FEEDSTOCK WITH REASONABLY LOW AROMATIC CONTENT

HEAVY OIL DILUTED WITH SIMILAR MATERIAL PREFERRED BY REFINERS TO THE USE OF MANY CONDENSATES (DUE TO HIGH LIGHT STRAIGHT RUN LIGHT NAPHTHA-FRACTIONS OF THESE CONDENSATES)

UPGRADING SCENARIOS

(A) BUILDING AT EXISTING REFINERIES

- CHEAPER CONSTRUCTION - ON-SITE CAMP NOT REQUIRED
- INFRASTRUCTURE

(B) USE CARBON REMOVAL AT

- SUNCOR - ADD PRETREATMENT FOR ASH
  - ADD H_2. ADD (3 STAGE)
  - SELL COKE TO ALTERNATE INDUSTRY
  - GO TO 150,000 BPCD
- SYNCRUDE - ADD H^2. ADD 1 STAGE
  - GO TO 450,000 BPCD

(C) NEW CONVERSION CENTRE AT FORT SASKATCHEWAN OR HARDISTY

DILUTED BITUMEN + HEAVY CRUDE

(D) SPLIT - VISBREAK & THERMAL IN FIELD

_ ALTERNATES

8. Environment/Infrastructure
9. Mine/Extraction Upgrading Interfaces - Fig. U-2
10. Feed Preparation - Fig. U-3
11. Conversion First Stage - Sheet A - Fig. U-4
12. Conversion First Stage - Sheet B - Fig. U-5
13. Conversion Second Stage - Fig. U-6
14. Hydrogenation - Fig. U-7

- LUNCH BREAK -

After lunch, Tom McCann continued his presentation on upgrading with the following viewgraphs:

15. Gas Processing and Hydrogen - Fig. U-8
16. Coking Development - Fig. U-11
17. Coke/Pitch Derivatives - Fig. U-12
18. Synthetic Crude Quality
19. Upgrading Scenarios

Tom responded to many questions during his presentation on upgrading. He covered the ground very thoroughly and provided the group with a good understanding of the State of the Art and relevant factors to be considered.

d) Utilities

Doug Kim addressed three utility considerations; namely,

- Combined Cycle
- Electric Power Supply
- Stand-alone Mine/Extraction Complex

The Combined Cycle presentation and discussion centred around Viewgraphs 20 and 21. Viewgraph 22 dealt with the Electric Power Supply. With the use of Viewgraph 23, Doug spoke to the Key Considerations relating to a stand-alone Mine/Extraction Complex.

COMBINED CYCLE UTILITY PLANT FOR TAR SANDS COMPLEX

REQUIREMENTS

- MUST HAVE VERY HIGH DEGREE OF RELIABILITY
- MUST BE FLEXIBLE TO MEET WIDELY AND IN INDEPENDENTLY VARIABLE STEAM AND ELECTRIC LOADS.
- MUST RIDE THROUGH UPSET AND EMERGENCY CONDITIONS WITHOUT AFFECTING SERVICE TO PROCESS.

SYNCRUDE

- BALANCED-DRAFT BOILER
- CONTINUOUS FRESH AIR SUPPLY
- NO BY-PASS OF GT EXHAUST GAS

ALSANDS

- FORCED DRAFT BOILER
- NO SUPPLEMENTARY AIR SUPPLY
- BY-PASS OF GT EXHAUST GAS TO ECONOMIZER

DESIGN CONSIDERATIONS

- LARGE QUANTITY OF GT EXHAUST GAS
    - LARGE HIGH TEMPERATURE DUCTS AND DAMPERS
    - COMPLICATED BOILER DESIGN
    - STEAMING ECONOMIZER
    - TURNDOWN
    - EXPOSURE TO LARGE TEMP. EXCURSION
- COMPLICATED CONTROL

COMBINED CYCLE UTILITY PLANT FOR TAR SANDS COMPLEX

PAGE 2

PROBLEMS

- LARGE NUMBER OF GT TRIPS
- ON GT TRIP, TRANSFER TO FULLY FIRED MODE UNRELIABLE, THUS TRIPPING BOILER

OPTIONS

- CONTINUOUS RUNNING STAND-BY FAN
- SUPERCHARGING GAS TURBINE
- ACCEPT THE TRIPS AS A FACT AND MINIMIZE IMPACT BY INSTALLING SMALLER UNITS

82-10-08

ELECTRICAL SUPPLY FROM AIS
FOR
TAR SAND PROJECT

CAPACITY

- WITH SINGLE LINE FROM MILDRED LAKE, APPROXIMATELY 50 MW AVAILABLE.
- WITH 1-LINE FROM MILDRED LAKE AND ANOTHER FROM EITHER CRAIGEND OR MITSUE, APPROXIMATELY 250 - 300 MW AVAILABLE.
- POWER FROM SLAVE RIVER PROJECT COULD BE AVAILABLE IN 1990's.

DRAGLINE SWING

- PRESENT 138 KV ALBERTA-B. C. TIE AFFECTED BY SYNCRUDE DRAGLINES. THE PROBLEM RECTIFIED ON SHORT TERM.
- THE TIE IS BEING UPGRADED TO 500 KV.
- IT IS ANTICIPATED THAT THE 500 KV TIE WITH FUTURE LOAD GROWTH WILL BE CAPABLE OF HANDLING SWINGS OF FUTURE DRAGLINE OPERATION.

SYSTEM STABILITY

- PLANNED EXPANSION OF THE DISTRIBUTION SYSTEM IN THE REGION IS ANTICIPATED TO BE CAPABLE OF HANDLING MAJOR LOAD CENTER.

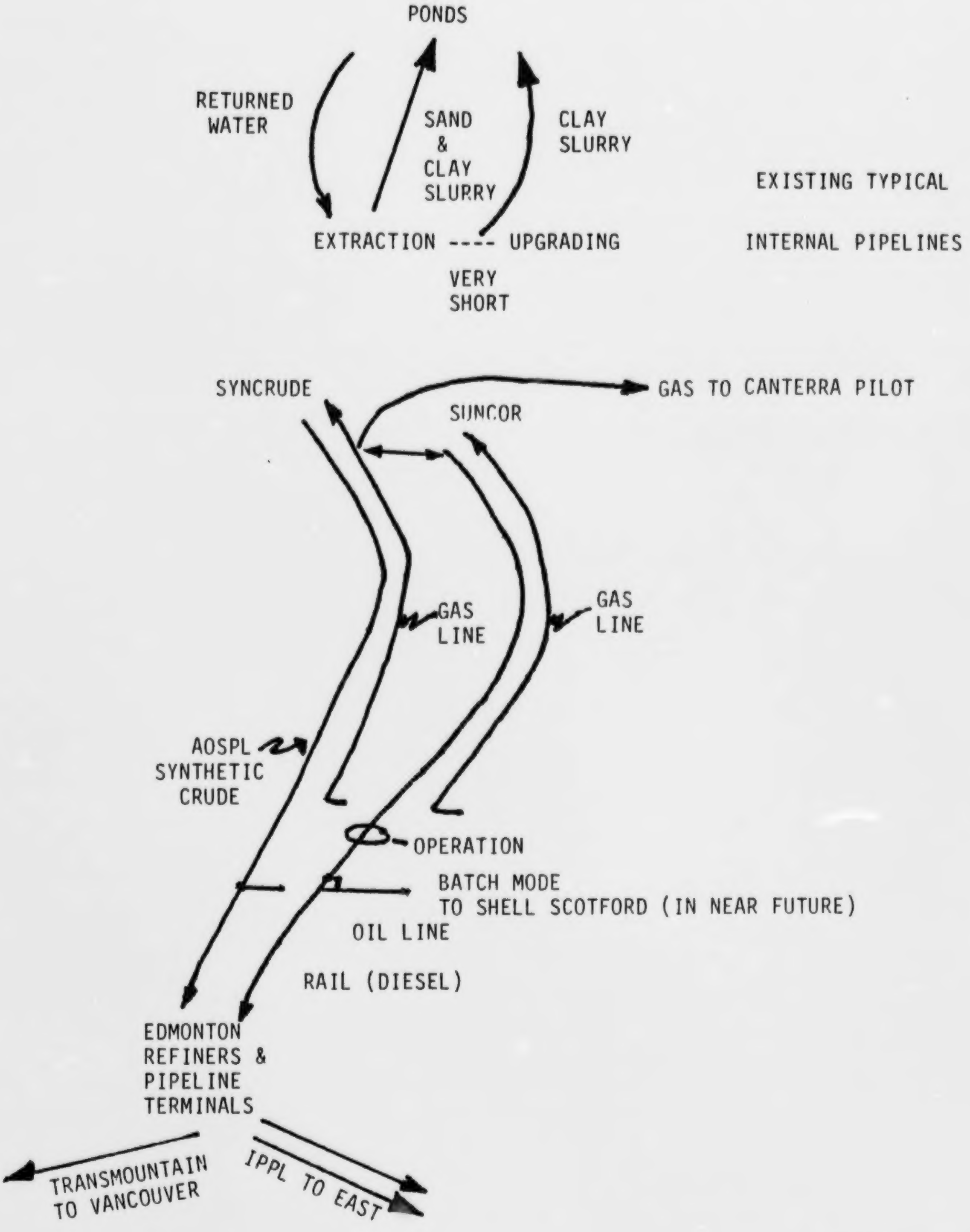
82-10-08

UTILITY CONSIDERATIONS
FOR
STAND-ALONE MINE/EXTRACTION COMPLEX

KEY CONSIDERATIONS

- OUTSIDE SOURCE OF FUEL REQUIRED
- LOW GRADE HEAT FROM UPGRADING FOR HOT WATER NOT AVAILABLE.
- HIGH PRESSURE STEAM FROM UPGRADING NOT AVAILABLE FOR POWER GENERATION.
- 100% MAKE-UP FOR STEAM AND HOT WATER.
- SYSTEM MUCH LESS COMPLEX THAN INTEGRATED PROJECT (STEAM LEVELS, USERS/PRODUCERS, OPERATING CASES).
- REQUIREMENTS FOR RELIABILITY AND FLEXABILITY LESS CRITICAL.
- MUST HANDLE INDEPENDENTLY VARIABLE POWER, STEAM AND HOT WATER REQUIREMENTS.

EXISTING PIPELINE SYSTEMS


PONDS
RETURNED WATER
SAND & CLAY SLURRY
CLAY SLURRY
EXISTING TYPICAL INTERNAL PIPELINES
EXTRACTION ---- UPGRADING
VERY SHORT
SYNCRUDE
GAS TO CANTERRA PILOT
SUNCOR
GAS LINE
GAS LINE
AOSPL SYNTHETIC CRUDE
OPERATION
BATCH MODE
TO SHELL SCOTFORD (IN NEAR FUTURE)
OIL LINE
RAIL (DIESEL)
EDMONTON REFINERS & PIPELINE TERMINALS
TRANSMOUNTAIN TO VANCOUVER
IPPL TO EAST

EXISTING PIPELINE
SYSTEMS

FIGURE P2

82-10-05

PIPELINES

NEW POSSIBILITIES IN MANY TRANSFERS BETWEEN OVERALL SYSTEM COMPONENTS

VIEWGRAPHS ONLY TO DEVELOP DISCUSSION AND TO NOTE WIDE RANGE OF POSSIBILITIES

PIPELINE OWNERSHIP MAJOR ISSUE

REGULATORY -ROYALTY, PRICE, TAX-ASPECTS MORE IMPORTANT THAN PIPELINE TECHNICALITIES IN SOME CASES

PIPELINE CORRIDORS IN AREA AND TO SOUTH MAY BE DEFINED ALREADY

PIPELINES ARE SERVICE FACILITIES

- HIGH CAPITAL
- LOW OPERATING
- LOW RISK (COMPARED TO OTHER SYSTEM PARTS)

PIPELINES
FIG. P 1

82-10-05

TYPE	FROM	TO LOCAL <5 MILES	TO LONG DISTANCE >10 MILES	NOTE
CONV. DIRTY	UPGRADING	→	REGIONAL IN SITU PLANTS	DILUENT
"	REGIONAL IN SITU	→	UPGRADING FT.McMURRAY	DILUTED BITUMEN
"	" "	→	UPGRADING SOUTH	" "
CONV. DIRTY OR CLEAN	REGIONAL IN SITU	→	UPGRADING SOUTH	PARTIALLY UPGRADED
CONV. DIRTY	UPGRADING	→	COLD LAKE (C)	DILUENT (SYN.COND.)
CONV. DIRTY	"	→	COLD LAKE (C)	SYNTHETIC CRUDE
H.P.DENSE PHASE	"	→	OIL FIELDS	CARBON DIOXIDE
H.P.GAS	"	→	UPGRADING (OTHER)	HYDROGEN (IN REGION ONLY)
H.P.GAS	"	→	EXTRACTION OR UPGRADING	MED.BTU GAS

"DIRTY" - CLEANLINESS OF PRODUCT NOT
OF HIGH IMPORTANCE

"CLEAN" - CLEANLINESS OF PRODUCT
HIGHLY IMPORTANT

NEW PIPELINE USE
POSSIBILITIES
FIG. P 3

82-10-05

NEW PIPELINE USE POSSIBILITIES

TYPE	FROM	TO LOCAL <5 MILES	TO LONG DISTANCE >10 MILES	NOTE
SLURRY	MINE	→ EXTRACTION		MINING BY DREDGING
SLURRY	MINE	→ MINE		OVERBURDEN BY DREDGING
SLURRY	MINE	→ UPGRADING		IN DIRECT COKING APPROACHES ONLY
SLURRY	UPGRADING	→ MINE		
CONV. DIRTY	EXTRACTION	* →	UPGRADING	DILUTED BITUMEN
"	UPGRADING	* →	EXTRACTION	DILUENT
CONV. DIRTY	UPGRADING (SMALL)	→	UPGRADING (MAJOR)	VISBROKEN
"	UPGRADING (CONVERSION)	→	UPGRADING (H_2)	UNHYDROTREATED
LIGHT HC	UPGRADING	→	EDMONTON FRACT.	SGL'S $(C_2's)C_3's$
CONV. CLEAN	UPGRADING	→	EDMONTON AREA	SPECIALTY LIQUID PRODUCTS

* RIVER CROSSING CLASSIFIED AS LONG

...CONT'D.

P 3

PIPELINE DESIGN FACTORS

- SLURRY - ECONOMICS (AND LIFE) ONLY PROBLEMS
- CONVENTIONAL "DIRTY" (LIQUID) - STRAIGHT FORWARD * SAND + CLAY VS SAND
- CONVENTIONAL "CLEAN" (LIQUID) - PROBLEM ONLY WHEN THIS TYPE OF PRODUCT COMBINED WITH "DIRTY" TYPE SERVICE.

  SPECIAL PROCEDURES - BUFFERS, PIGS-INTERFACE SLOP NEEDED

  - IN EXTREME CASE RERUN PRODUCT
- M.P. GAS - H_2 (AND CO) SAFETY ONLY CONCERN - MANY USABLE LINES NOW
- DENSE PHASE (SUPERCRITICAL) - MANY CO_2 LINES IN USE
  - NO SPECIAL PROBLEMS HERE. (MAY NEED CO_2 LIQUIFACTION STEP TO ELIMINATE H_2)
- LIGHT HC - CONVENTIONAL VIA COCHIN
- BATCHES/BLENDS OF (A) SYNCRUDE & SGL'S - BATCH CONCERNS NOTED ABOVE - RERUN SGL'S

PIPELINE DESIGN
FACTORS
FIG. P 5

82-10-05

POSSIBLE ADDED MIXED USE CASES

- SPECIAL MIXED USE CASES

    BITUMEN PLUS CO_2

    BITUMEN PLUS SGL'S (NOTE VARIOUS FORMS)

    BITUMEN PLUS SGL'S + CO_2

    VISBROKEN BITUMEN PLUS CO_2

    " " " SGL'S

    " " " SCL'S + CO_2

ALL NEED RESEARCH ON PHASE EQUILIBRIA ON HOW TO PUT CRUDE BACK TOGETHER AT UPGRADER

WATER - EMULSION
ANNULUS
SPECIAL SOLVENTS, E.G. TOLUENE
ADDITIVES - A LA ALYESKA
LINING - FLOW
- CORROSION

POSSIBLE ADDED
MIXED USE CASES

FIG. P 6

DILUTED BITUMEN LOOP SYSTEM POSSIBILITY

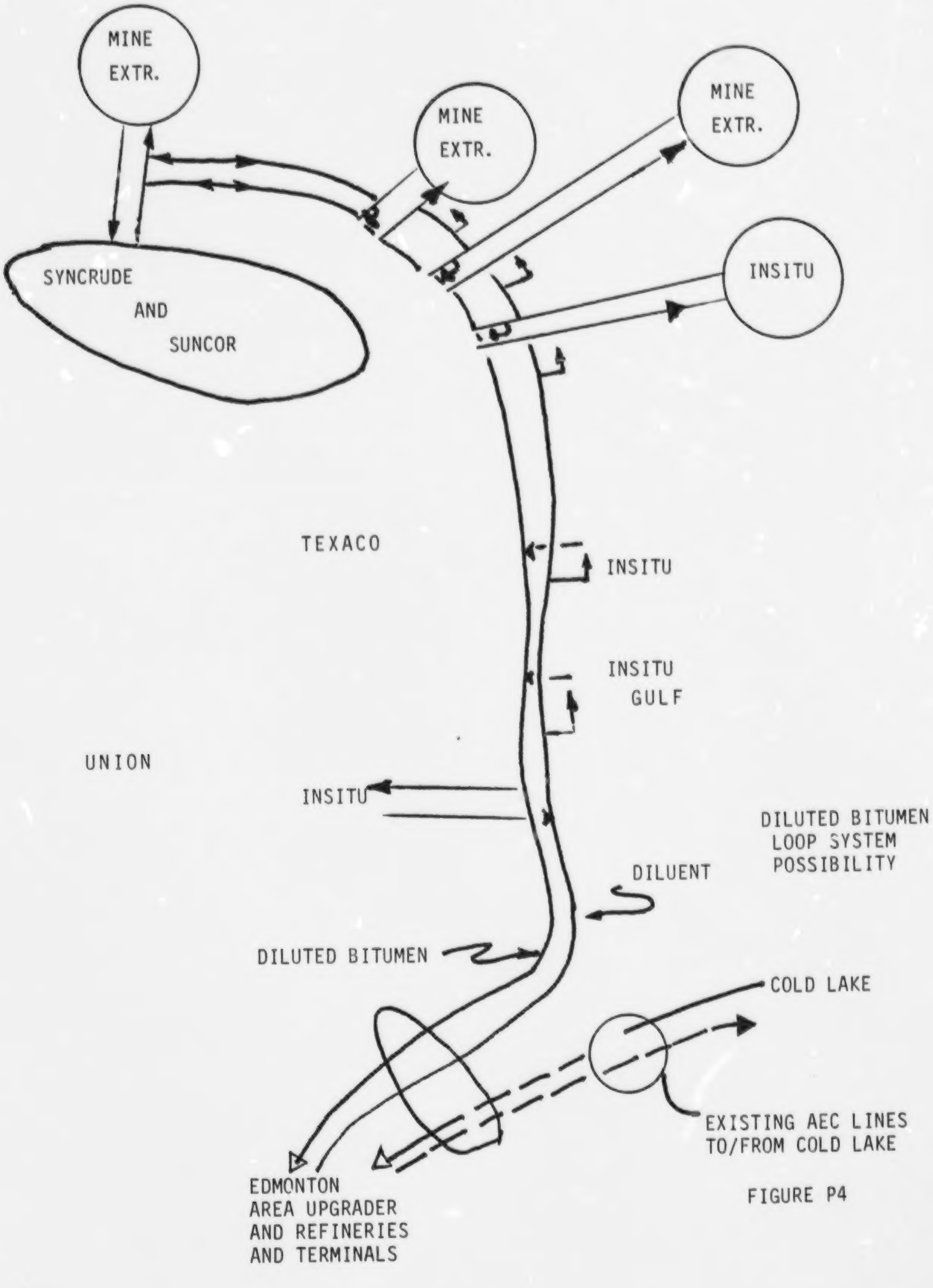
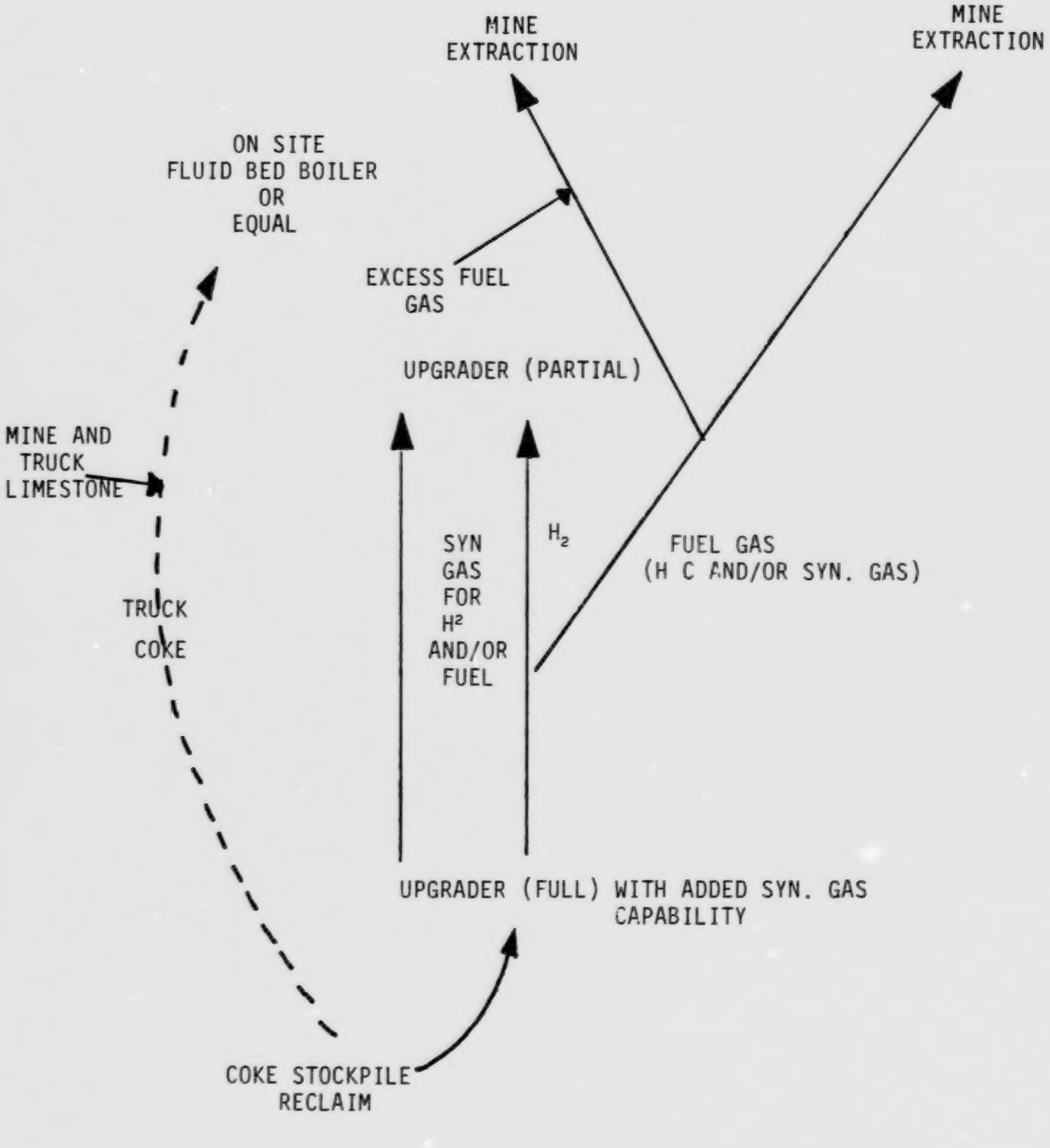

MINE EXTR.
MINE EXTR.
MINE EXTR.
SYNCRUDE AND SUNCOR
INSITU
TEXACO
INSITU
INSITU GULF
UNION
INSITU
DILUTED BITUMEN LOOP SYSTEM POSSIBILITY
DILUENT
DILUTED BITUMEN
COLD LAKE
EXISTING AEC LINES TO/FROM COLD LAKE
EDMONTON AREA UPGRADER AND REFINERIES AND TERMINALS

FIGURE P4

POSSIBLE FUEL GAS AND HYDROGEN NETWORK


MINE EXTRACTION
MINE EXTRACTION
ON SITE FLUID BED BOILER OR EQUAL
EXCESS FUEL GAS
UPGRADER (PARTIAL)
MINE AND TRUCK LIMESTONE
SYN GAS FOR H² AND/OR FUEL
H_2
FUEL GAS (H C AND/OR SYN. GAS)
TRUCK COKE
UPGRADER (FULL) WITH ADDED SYN. GAS CAPABILITY
COKE STOCKPILE RECLAIM

POSSIBLE FUEL GAS
AND HYDROGEN LINES
BETWEEN REMOTE SYSTEM
COMPONENTS

FIGURE P-7

82-10-05

e) Pipelining

Tom McCann presented his material on pipelines using the following viewgraphs:

24. Existing Pipeline System - Fig. P.2
25. Pipelines - Fig. P.1
26. New Pipeline Use Possibilities
27. New Pipeline Use Possibilities
28. Pipeline Design Factors
29. Possible Added Mixed Used Cases. . .
30. Diluted Bitumen Loop System Possibility
31. Possible Fuel Gas & Hydrogen Network

During the course of discussions on Tom's presentation on pipelines, it was noted that:

- Pipeline Inch/Mile Costs are currently in the range of $23 - $24,000 per mile
- Pipeline technology has changed very little in recent years.
- Pipeline costs have been relatively stable for the past 2 - 3 years; particularly on small diameter pipelines. Those large diameter union jobs have shown decided increases over the last 12 months. It is recognized that over the last decade Canadian pipeline costs have indeed spiraled at a pace greater than other industrial sectors.

Before concluding the deliberations for the day, the following decisions were made:

- The group would reconvene on Tuesday of next week and continue through to Friday.
- The sessions would commence at 9:00 A.M. and conclude at 4:30 P.M. with lunch being brought in.
- Tuesday would be devoted to Topics 9, 11 and 12.
- For Topic 13, three sub-groups would be formed, with Messrs. Guthrie, McCann and McClement being the group leaders.

"END OF DAY"

The Concept Development Team reconvened at 9:00 A.M. on Tuesday, October 12, 1982.

10. REVIEW/MODIFY/ACCEPT RESULTS OF TASK II WORK DONE BY TECHMAN

John Porteous presented the preliminary outline of the Task 2 write-up, "A Description of a Tar Sands Mega-Project", for discussion and input from the Concept Development Team. Copies of the vugraphs are attached to these Minutes.

John Porteous advised that Techman had chosen a Hypothetical 100,000 BPCD Synthetic Crude Oil Project rather than describe an existing or proposed project, although in many cases data is extrapolated from an actual project where data was available in the public domain. (Public Domain Data in Techman's files includes ERCB applications, submissions to various government agencies, manufacturers, trade unions, etc., and announcements by owners as reported in the press).

The discussion of the presentation led to numerous suggested changes and additions which are summarized by section, in the following paragraphs:

In the Economic section, it was suggested that "Resource Utilization" be included with other items affecting cost. The presentation, assumptions and exclusions that went into the cost numbers were discussed and tabled for further development by Techman to ensure that the numbers provide a basis for comparison with other cases and that it would be a fair and accurate representation of the hypothetical plant.

It was suggested that under the Economics section a sub-section be added that dealt with Sustaining or Deferred Capital. It was also proposed that the sub-section on Annual Operating Costs include the makeup of the Operating Cost Numbers. It was pointed out that Revenue Forecasts were also highly dependent on the production rates achieved. Under the Economics sub-section it was suggested that reference also be made to:

- Construction Time
- Time to Achieve Planned Production
- Product Value/Quality

It was also proposed that a sub-section on Schedule be added to cover factors such as Inflation, Commitment/Expenditure Profiles, etc.

In the section on Financing, it was suggested that the Joint Ownership Consortium might include participation by private industry and government corporations. It was further suggested that parts of the plant and/or infrastructure could be owned by others outside of the consortium.

The Political section was amended to include the 40-year life of the project, which includes the 30-year operating life, to indicate how changes in government policy can affect a project over a considerable time frame. In the section on non-fiscal matters, "Offsite Infrastructure/Location" was added.

The Environmental and Regulatory section was amended to include the concept that permitting and reporting requirements are ongoing and become directionally more stringent.

In the Societal section, it was agreed that the population increase should be shown as "in excess of 12,000".

In the Technology section, it was agreed that the wording be revised to incorporate the point that design redundancy and a special design allowance philosophy, is required for tarsands plants to minimize exposure to technological risk and ensure that the required reliability is achieved.

At this point the schedule was discussed to provide a basis of understanding for the Project Execution section. It was agreed that the owners' decision points should be included on the schedule. There would be an initial decision point when the "Rules of the Game" were in place regarding fiscal and non-fiscal matters.

At this time the owner would have a certain quality of cost estimate available. There would be a second decision point approximately 1-1/2 years later, when a better quality cost estimate is available.

It was agreed that the Commercial Terms item should be deleted from the Development and Execution section and included in the Economics/ Political portion of the write-up. It was agreed to add the following items:

1. Provision of Extra Infrastructure in the region and

2. The long-term overlap of the project execution and operations phases, that is typical of mega projects.

It was also agreed to add the fact that mega projects are built by union labour, and that the project typically places large demands on available resources.

The Operations section is to be amended to include the requirement for experienced manpower in a remote location, and the facilities, training, etc., accomplish this. The startup demands and the length of time to achieve stable operations will also be added. The unusual maintenance requirements are also to be incorporated.

- LUNCH BREAK -

11. GENERAL DISCUSSION ON TECHNICAL/OPERATIONAL/ PROJECT DEVELOPMENT/PROJECT APPROVAL PROBLEMS, CONSIDERATIONS AND CONSTRAINTS THAT SHOULD BE TAKEN INTO ACCOUNT IN TASKS 3 AND 4 DELIBERATIONS

The Chairman invited each team member to identify approximately five considerations, constraints and/or problems that he judged to be most important and needed to be taken into account in Tasks 3 and 4. The various points as developed were compiled and are listed below:

- Confidence in government agreements, policies, and direction over long time frame.
- Project Facilities to be investment effective:
    - alternative scale
    - technology - other opportunities
    - measurable - rate of return/size
- Environmental/Resource/Recovery Guidelines in place based on sound cost benefit analysis.
- Consideration on how to design an operating organization that will accommodate a technology plant scale and changing social environment.

- - - - - - - - - - - - -

- Resource (lease?) available to support the level of the chosen plant.
- Regulatory approvals for resource recovery and waste disposal.

  Technical Risk

- - - - - - - - - - - - -

- Improve the approval process.
- Commercial terms:
    - royalty, taxes - government
    - pricing - utility
      - free market
- Environmental considerations:
    - understood
    - deal with changes

- People - housing, movement, infrastructure
- Technical - processes, non-inflationary process
  - governments treat tarsands projects as special

- - - - - - - - - - - -

- Commercial arrangements in place early and across the board. Flexible (royalties, taxes, pricing)
- Location to affect decision:
  - People - operating points of view
    - construction
    - service
    - housing
    - maintenance
- Plant Size:
  - proven processes
  - equipment
  - management and maintenance of operation

- - - - - - - - - - - -

- Markets - pricing
- Problem of dealing with multiplicity of permits and licences.
- Owners' Management of Risks
  - present value

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- Government Policy related to pricing, taxes and royalties
- Scale - size of project
- Ownership and Structure
- Cost and Schedule (economics)
- Technology (type available)

- - - - - - - - - - - -

- Rate of Return to Owners:
  - commercial terms, cost, etc.
  - must be commercially viable
- Execution:
  - cost schedule, resources
  - building facilities
- Minimize Risk:
  - Technology - not prototype, extrapolation of existing technology
- Energy Self-sufficiency - do not depend on outside sources
  - improve reliability
- Integrated Project Problems:
  - bitumen production vs upgrading

- - - - - - - - - - - -

- Determine Objective:
  - Individual Entrepreneur
vs
National Interest

Identify what is Natinal Benefit and who pays for infrastructure.

"END OF DAY"

THE PARAMETERS USED TO DESCRIBE THE MEGA-PROJECT ARE CATEGORIZED INTO THE FOLLOWING FRAMEWORK:

- ECONOMICS
- POLITICAL
- ENVIRONMENTAL AND REGULATORY
- SOCIETAL
- TECHNOLOGY
- DEVELOPMENT AND EXECUTION
- OPERATION
- MARKET AND PRODUCT QUALITY
- RISK AND IMPACT

ECONOMIC

- INITIAL CAPITAL COSTS

THE CAPITAL COSTS OF A TAR SANDS MEGA-PROJECT CAPABLE OF PRODUCING 100,000 BARRELS PER CALENDAR DAY (AVERAGE FOR A YEAR'S OPERATION) OF SYNTHETIC CRUDE ARE VERY MUCH A FUNCTION OF:

- CRUDE QUALITY.
- DEGREE OF ENERGY SELF SUFFICIENCY.
- ENVIRONMENTAL EMISSION STANDARDS.
- COKE AND/OR OTHER HEAVY MATERIAL DISPOSITION.
- TRADE OFFS BETWEEN CAPITAL COSTS AND FUTURE OPERATING COSTS IN AREAS OF ENERGY EFFICIENCY, OPERATIONAL RELIABILITY, MAINTENANCE COSTS, FUTURE CAPITAL COSTS, OTHER OPERATING COSTS.

BASED ON ASSUMPTIONS MADE WITH RESPECT TO THE ABOVE AND USING ALSANDS, SYNCRUDE AND OTHER DATA THAT IS IN THE PUBLIC DOMAIN, THE FOLLOWING HAVE BEEN ESTIMATED (1982 $):

INITIAL CAPITAL COST OF PHYSICAL FACILITIES (EXCLUDING INFRASTRUCTURE REQUIREMENTS OUTSIDE OF LEASE SITE, I.E. PIPELINES, POWER, URBAN AND RESIDENTIAL REQUIREMENTS, ETC.)	$50,000 BPCD
OWNER PREPRODUCTION COSTS (ASSUMED AT 1/3 OF CAPITAL COST OF PHYSICAL FACILITIES)	$17,000/BPCD
TOTAL CAPITAL COSTS ON $6.7 BILLION (1982 $)	$67,000/BPCD

- ANNUAL OPERATING COSTS

THE ANNUAL OPERATING COSTS, PAST THE START-UP PERIOD AND THE TIME REQUIRED (YEARS) TO ACHIEVE THE FORECAST AVERAGE RATE OF PRODUCTION (100,000 BPCD) ARE BASED ON INFORMATION IN THE PUBLIC DOMAIN. THIS FIGURE IS ESTIMATED AT $19 PER BARREL (1982 $)

THE ABOVE NUMBER EXCLUDES RETURN ON INVESTMENT AND INTEREST CHARGES ON MONEY.

- REVENUES

THE GROSS REVENUE GENERATED OVER THE LIFE OF THE PRODUCTION PERIOD (25 - 30 YEARS) IS A FUNCTION OF THE PRICE RECEIVED FOR THE SYNTHETIC CRUDE, WHICH IF TIED TO THE WORLD CRUDE PRICE, CONSTITUTES A MAJOR AREA OF RISK.

- ECONOMICS

THE ECONOMICS OF A TAR SANDS MEGA-PROJECT TO THE INVESTOR ARE A FUNCTION OF THE FINANCIAL AND TAX REGIME THAT WILL PREVAIL OVER THE LIFE OF THE PROJECT, INCLUDING THE PRODUCTION PERIOD. THE FINANCIAL AND TAX REGIME, WHICH INCLUDES ITEMS SUCH AS ROYALTY, PGRT, FEDERAL AND PROVINCIAL TAXES, ARE OUTSIDE OF THE CONTROL OF THE INVESTOR, HAVE TO BE NEGOTIATED BY THE POTENTIAL INVESTOR AND ARE SUBJECT TO CHANGE BY THE GOVERNMENTS DURING THE LIFE OF THE PROJECT.

- FINANCING

THE TWO PRINCIPLE WAYS OF FINANCING A MEGA-PROJECT ARE:

- JOINT OWNERSHIP CONSORTIUM, WITH EACH OWNER FINANCING ITS EQUITY PARTICIPATION IN WHATEVER WAY IS BEST FOR THE INDIVIDUAL INVESTOR.

- PROJECT FINANCING BY BANKS OR OTHER LENDING INSTITUTIONS.

- OTHER

THE DEVELOPMENT TIME FROM INITIAL CONCEPTION TO THE DECISION TO PROCEED IS IN THE ORDER OF 4 YEARS, INVOLVES MANY APPROVAL STEPS AND THE NEGOTIATION OF COMMERCIAL TERMS. DURING THIS PERIOD THE INVESTOR WILL HAVE EXPENDED MANY MILLIONS OF $ WITHOUT KNOWING WHETHER THE FINAL NEGOTIATED RULES OF THE GAME WILL RESULT IN A FINANCIALLY AND ECONOMICALLY VIABLE PROJECT.

POLITICAL

- THE FISCAL AND TAX REGIME WHICH WILL PREVAIL DURING THE LIFE OF THE PROJECT AND THE OPERATION OF THE PLANT ARE CONTROLLED BY THE FEDERAL AND PROVINCIAL GOVERNMENTS AND ARE SUBJECT TO CHANGE DURING THE LIFE OF THE PROJECT.

- THE FISCAL AND TAX REGIME (RULES OF THE GAME) ARE NOT ESTABLISHED UP FRONT AND THE POTENTIAL INVESTOR HAS SPENT SUBSTANTIAL MONIES (MILLIONS OF $) IN DEVELOPMENT ACTIVITIES BEFORE THEY ARE IN PLACE, WITHOUT KNOWING WHETHER THEY WILL RESULT IN A ECONOMICALLY VIABLE PROJECT AND WITHOUT KNOWING WHEN THEY MIGHT BE CHANGED.

- NON FISCAL MATTERS THAT ARE EITHER CONTROLLED BY OR INFLUENCED BY THE GOVERNMENTS IN A MAJOR WAY REQUIRE A GREAT DEAL OF DEVELOPMENT, TIME, DISCUSSIONS AND NEGOTATIONS WITH THE TWO GOVERNMENTS, WHO DO NOT ALWAYS HAVE THE SAME OBJECTIVES. THESE NON FISCAL MATTERS INCLUDE CONSIDERATIONS SUCH AS:
    - PROJECT SITE AGREEMENTS;
    - REGIONAL AND CANADIAN INDUSTRIAL BENEFITS;
    - PROVINCIAL AND CANADIAN CONTENT;
    - EMPLOYMENT AND BUSINESS OPPORTUNITIES FOR PEOPLES INDIGENOUS TO THE AREA;
    - LABOUR PLANNING;
    - SOCIO - ECONOMIC IMPACTS AND BENEFITS;
    - URBAN AND RESIDENTIAL;
    - ENVIRONMENTAL.

- BECAUSE OF THE SIZE, HIGH PROFILE, AND VISIBILITY OF A MEGA-PROJECT, GOVERNMENTAL DEPARTMENTS AND AGENCIES ARE DISPOSED TO USE THE PROJECT AS A VEHICLE FOR SOLVING SOME OF THE PROBLEMS OF THE REGION AND THE COUNTRY. THEY ARE THEREFORE INCLINED TO IMPOSE A GOOD DEAL OF INFLUENCE AND CONTROL, ON THE NON FISCAL MATTERS DURING THE EXECUTION OF THE PROJECT.

ENVIRONMENTAL AND REGULATORY

ENVIRONOMENTAL IMPACT IS WIDE SPREAD IN THE DEVELOPMENT REGION.

- SURFACE DISTURBANCES
    - PROJECT FACILITIES - 6,000 - 10,000 HA
    - URBAN & UTILITY CORRIDOR DEVELOPMENT - APPROXIMATELY 5,000 HA
- ON-SITE LAND CLEARINGS

- TAILINGS POND	2,100 - 2,800 HA
- MINE	2,800 - 3,900 HA
- PLANTSITE	300 - 1,100 HA
- OTHER FACILITIES	700 - 2,300 HA

- WATER REQUIREMENTS MAY APPROACH 2.8 CUBIC METERS/SEC.
- UPGRADING FACILITY MAY EMIT 60 - 90 METRIC TONS/DAY OF SULPHUR.
- WATER VAPOUR EMISSIONS FROM TAILINGS, VENTS, STACKS, COOLING TOWER, AND PROCESS FURNACES MAY RANGE FROM 50 - 70 x 10^6 KG/DAY.
- REQUIRE COORDINATED PLANNING WITH REGIONAL AUTHORITIES IN MATTERS OF ROADS, RAIL, URBAN INFRASTRUCTURE, AND LOCAL ENTREPRENURIAL OPPORTUNITIES.

ENVIRONMENTAL AND REGULATORY

REGULATORY PERMITTING REQUIREMENTS IN ALL FACILITY AREAS SEVERELY IMPACT SCHEDULE, PLANT LOCATION AND FACILITY LAYOUTS AND OPERATION.

- REQUIRE IN THE ORDER OF 200 MAJOR PERMITS.
- TOTAL PERMITS AND APPROVALS FROM VARIOUS GOVERNMENT DEPARTMENTS RANGE FROM 1,000 TO 3,000.
- APPROVALS MAY BE WITHHELD UNTIL SITE SELECTION AND LAYOUT ENSURE THAT BITUMEN UNDER THE TAILINGS POND IS UNECONOMICAL TO RECOVER.
- MAJOR PERMITTING AND APPROVALS REQUIRE 2 - 3 YEARS TO PREPARE, SUBMIT, AND GAIN APPROVALS; AND MUST INCLUDE DETAILED DISCLOSURE OF PLANS IN TECHNICAL, ENVIRONMENTAL AND SOCIO-ECONOMICAL AREAS.
- HIGH DEMAND FOR WATER AND RELIABILITY REQUIREMENTS FOR POWER AND NATURAL GAS FORCE SECONDARY CONNECTIONS TO PROVINCIAL POWER GRIDS AND PIPELINES, CAUSING FURTHER REGULATORY AND ENVIRONMENTAL CONCERNS OUTSIDE THE SITE BOUNDARY.
- LEGISLATED BITUMEN RECOVERY REQUIREMENTS ARE IN EXCESS OF THOSE REQUIRED IN OTHER TECHNOLOGY AREAS.

SOCIETAL

IN RELATION TO EXISTING POPULATIONS IN NORTHEASTERN ALBERTA, THE INFLUX OF A WORKFORCE, DEPENDENTS, AND SERVICE SECTOR REPRESENTS A LOCALLY AND REGIONALLY SIGNIFICANT INCREASE IN POPULATION.

- CONSTRUCTION WORK FORCE - PEAK AT 6,000 PLUS
- OPERATIONS WORK FORCE - APPROXIMATELY 4,000
- AT START-UP, MINE AND PLANT OPERATIONS WOULD RESULT IN A DIRECT (WORK FORCE) RELATED AND INDIRECT SERVICE-SECTOR RELATED PERMANENT POPULATION INCREASE OF ABOUT 12,000.

POTENTIALLY, NEW TOWNSITES ARE REQUIRED AND/OR EXISTING TOWNSITE INFRASTRUCTURES ARE SEVERELY STRAINED.

TECHNOLOGY

LITTLE OR NO NON-COMMERCIALLY PROVEN PROCESS TECHNOLOGY IS USED IN THE FACILITIES DESIGN IN ESSENTIAL PRODUCTION AREAS.

LARGE PRODUCTION REQUIREMENTS NECESSITATE AN ASSEMBLAGE OF THE LARGEST COMPONENTS AVAILABLE OFTEN MAKING A PROTOTYPE PLANT FROM A MECHANICAL OR OPERATING VIEWPOINT.

TO GIVE PROCESS DESIGNERS THE ABILITY TO APPLY NON TAR SANDS EXPERIENCE OR NEW TECHNOLOGY, IT IS NECESSARY TO:

- PLAN FOR PILOT AND ENGINEERING DEVELOPMENT WORK IN THE CONCEPTUAL DESIGN PHASE
- RECOGNIZE THE COST OF THIS WORK IN RELATION TO THE SCHEDULE
- RECOGNIZE THE IMPACT ON THE DESIGN OF ADJACENT UNITS THAT INTEGRATE WITH THE PILOT OPERATION

THE MAJOR UNIT OPERATIONS ARE HIGHLY INTEGRATED TECHNICALLY, THEREFORE A HIGH DEGREE OF REDUNDANCY AND INDIVIDUAL OVERCAPACITY IS FOUND TO MINIMIZE PRODUCTION UPSET, RISK, AND ENSURE RELIABILITY.

DEVELOPMENT AND EXECUTION

REMOTE PROJECT LOCATION REQUIRES BOTH TEMPORARY AND PERMANENT ON-SITE PERSONNEL ACCOMMODATION.

- REQUIRES A FULLY SERVICED CAMP DURING CONSTRUCTION TO ACCOMMODATE UP TO 6,000 PLUS WORKERS
- DURING OPERATION, TEMPORARY WORK FORCES CAN APPROACH 2,000 PEOPLE

MEGA-PROJECTS HAVE COMPLEXITIES IN THE FOLLOWING AREAS:

- CONTRACTUAL AGREEMENTS
- MANAGEMENT STRUCTURES
- COMMERCIAL TERMS
- EXECUTION PLANS

HIGH COSTS OF ON-SITE CONSTRUCTION REQUIRES LARGE OFF-SITE PREASSEMBLY FACILITIES WHICH CAN ACCOUNT FOR 10 - 15% OF THE FIELD LABOUR. THIS ADDS TO THE COMPLEXITY IN CONSTRUCTION EXECUTION AND MANAGEMENT.

MEGA-PROJECTS ARE PRESENTLY CONSTRUCTED UNDER "SITE LABOUR AGREEMENTS".

- NO STRIKE - NO LOCK-OUT
- GIVES BARGAINING STRENGTH TO UNIONS DURING NEGOTIATION PERIODS

DEVELOPMENT AND EXECUTION

DIRECT LABOUR IMPACT IS IN THE ORDER OF 50,000,000 MANHOURS.

THE HIGH LEVEL OF EXPERTISE REQUIRED TO PROJECT MANAGE A SURFACE MINEABLE TAR SAND MEGA-PROJECT NECESSITATES LARGE INTERNATIONAL COMPANIES FOR EFFECTIVE EXECUTION.

MEGA-PROJECTS AMPLIFY THE CYCLIC CHARACTERISTICS OF THE CONSTRUCTION INDUSTRY.

OPERATIONS

OPERATIONS MANPOWER IS IN THE RANGE OF 4,000 PEOPLE.

A MAJOR SETBACK IN OPERATIONS CAN BE CATASTROPHIC DUE TO LENGTH OF TIME INVOLVED FOR REPLACEMENT OR REPAIRS AND THE SIGNIFICANT REVENUE AFFECTED.

MARKET AND PRODUCT QUALITY

THE HIGH PRODUCTION RATE OF SYNTHETIC CRUDE OIL FROM A MEGA-PROJECT IS A SIGNIFICANT PERCENTAGE OF INDUSTRIAL CAPACITY.

A 100,000 BPD (15,900 CUBIC METER PER DAY) PLANT WOULD PROVIDE:

- % OF ALBERTA'S PRESENT CONVENTIONAL CRUDE - 9.5%
- % OF ALBERTA'S CONVENTIONAL CRUDE SUPPLY BY 1990 (EXPECTED DECLINE TO 106×10^3 CUBIC METERS PER DAY - 15%

PROJECT MUST BE ECONOMICALLY JUSTIFIABLE AS DESIGNED TO PRODUCE ITS STANDARD SYNTHETIC CRUDE PRODUCT FOR 25 - 30 YEARS.

CONVENTIONAL CRUDE REFINERIES MUST ACCEPT AN INCREASING SYNTHETIC BLEND RATIO AS CONVENTIONAL CRUDE SUPPLIES DECLINE.

MARKETING STRATEGIES MUST BE FORECAST FOR 20 + YEARS.

RISK AND IMPACT

POLITICAL

GOVERNMENT REGULATORY AGENCIES WHICH EXERCISE CONSIDERABLE INFLUENCE TEND TO IMPOSE RESTRICTIONS ON EXISTING TECHNOLOGY BEYOND ECONOMICALLY PRACTICAL LIMITS.

THE HIGH PROFILE OF A MEGA-PROJECT AND ITS IMPORTANCE TO KEY GOVERNMENT POLICIES MAY NECESSITATE INTERVENTIONS WHICH CONFLICT WITH THE INTEREST OF THE PROJECT.

A MEGA-PROJECT IS CONCEIVED AND CONSTRUCTED THROUGH 2 OR MORE POLITICAL TERMS AND SHIFTS IN GOVERNMENT'S DIRECTION CAN IMPACT THE PROJECT.

TECHNICAL

RISK AVERSION IS CRITICAL IN SELECTION OF TECHNOLOGY TO PREVENT TOTAL FACILITY FAILURE.

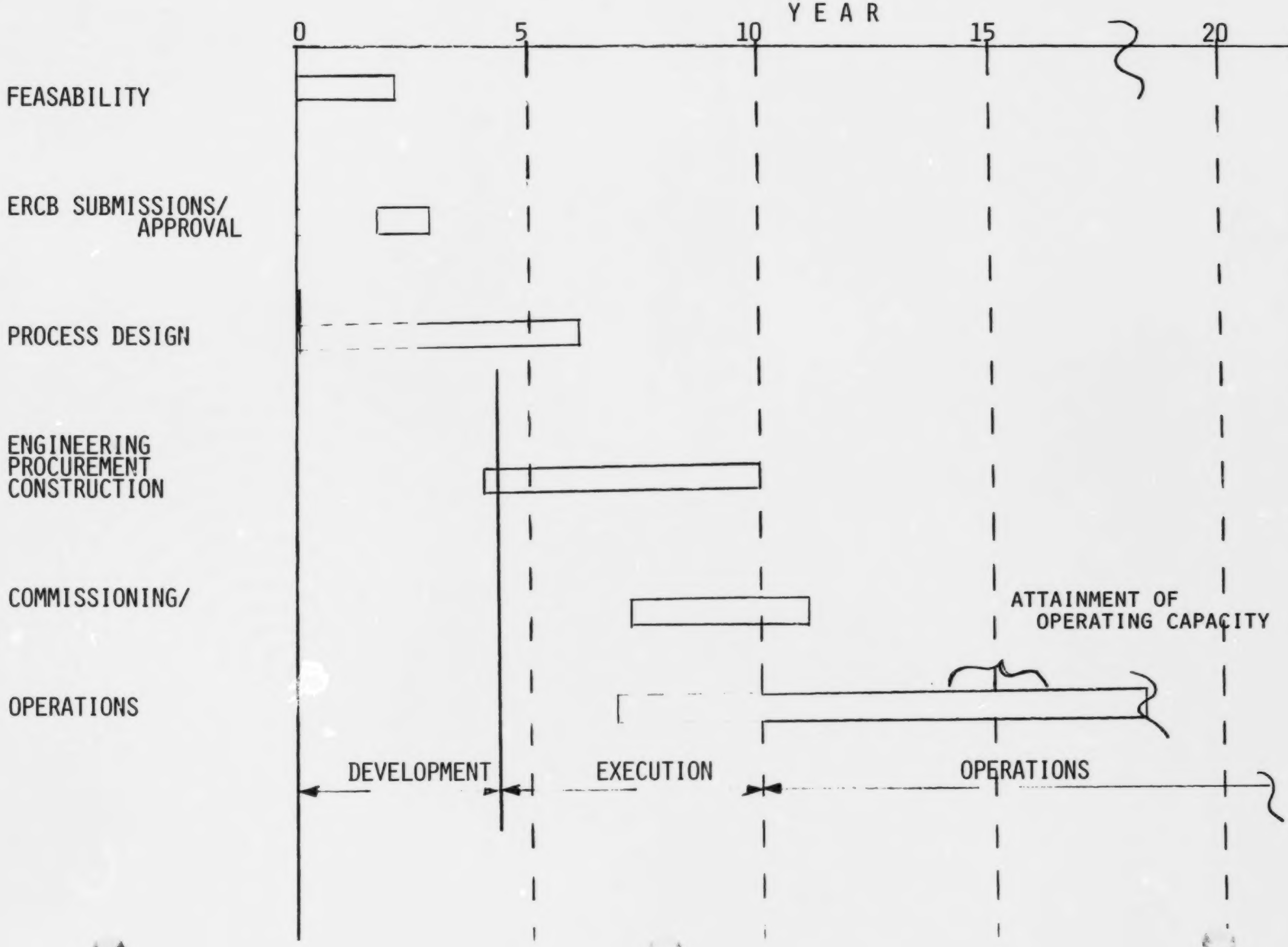
ECONOMICAL

MEGA-PROJECTS TEND TO COMPETE FOR RESOURCES AND/OR TAX AVAILABLE RESOURCES, THUS INCREASING $ PRESSURES.

INTEREST RATES, INFLATION, COMMODITY PRICES ARE HIGH RISK ITEMS OVER A 25 - 30 YEAR SPAN.

COMMERCIAL TERMS ARE NEGOTIATED DURING THE DEVELOPMENT PHASE AND WHILE MILLIONS OF DOLLARS ARE EXPENDED, THE FINAL RULES FOR THE PROJECT ARE NOT KNOWN.

TAR SANDS MEGA-PROJECT - LIFE CYCLE



MEGA-PROJECT

THE GOAL OF THIS REPORT IS TO STATE A SERIES OF PARAMETERS THAT WHEN JUDGED IN TOTAL COULD BE USED TO DESCRIBE AN ALBERTA SURFACE - MINEABLE OIL SANDS MEGA-PROJECT.

THE SPECIFIC OBJECTIVES TO BE ADDRESSED ARE:

- TO DESCRIBE A MEGA-PROJECT SIZED SURFACE MINEABLE OIL SANDS PLANT BY IDENTIFYING ITS SIGNIFICANT PARAMETERS.
- TO CHARACTERIZE THESE PARAMETERS QUANTITATIVELY IF POSSIBLE OR QUALITATIVELY.

SCOPE DEFINITION OF THE HYPOTHETICAL MEGA PLANT

THE DESCRIPTION IS MEANT TO APPLY GENERALLY TO A PLANT AND ASSOCIATED INFRASTRUCTURE - NOT TO A SPECIFIC EXISTING OR PROPOSED FACILITY.

THE PLANT FACILITIES ARE LOCATED IN THE ALBERTA SURFACE MINEABLE ORE RESERVE AREA (I.E. FORT McMURRAY AND NORTH LOCATION).

THE PLANT WILL HAVE THE CAPACITY TO PRODUCE 100,000 BPCD OF SYNTHETIC CRUDE OIL AND WILL CONSIST OF THE FOLLOWING TYPES OF EQUIPMENT AND FACILITIES.

- MINE
  - DRAGLINE AND/OR BUCKETWHEEL EXCAVATOR EQUIPMENT
  - TAILINGS HANDLING FACILITIES
- EXTRACTION
  - CLARK HOT WATER PROCESS
- UPGRADING
  - FLUID COKING, HYDROTREATING, DESULPHURIZATION
- UTILITIES
  - EQUIPMENT AND PROCESSES TO PROVIDE ENERGY SELF SUFFICIENCY AND TO MAKE USE OF COKE PRODUCTS
- OTHER
  - ALL SUPPORT EQUIPMENT AND FACILITIES REQUIRED FOR OPERATION OF THE FACILITIES (ADMINISTRATION, MAINTENANCE, PRODUCT STORAGE AND INTER-CONNECTING FACILITIES WITHIN THE SITE BOUNDARY).
  - THE PLANT FACILITIES ARE HIGHLY INTEGRATED TECHNICALLY AND PHYSICALLY.
  - THE PRODUCT QUALITY IS A SYNTHETIC CRUDE OIL OF A 35° API GRAVITY.

82-10-08

The Concept Development Team reconvened at 9:00 A.M. on Wednesday, October 13, 1982, and continued with discussions from the previous day.

- Economic Viability:

  Objective - Free Enterprise
  - National Interest
  - Insurance

- Need Guarantees - R.O.I/Market

- Mining Economic Needs:

  - Flexible regulations to permit developer to set guidelines for resource recovery/reclamation

- Plant Size - Scale:

  - Optimum practical balance for each system

- Simplicity:

  - Maximum reliability, hence output

- - - - - - - - - - - -

- DCF Return on Investment:

  - Payout period
  - Capital up front

- Risk - Technological Decision:

  Key - operable plant at startup
  - extended startup
  - fix-up - results in injection of capital
  - result - reduced production

- - - - - - - - - - - -

- Non-commercial Terms in Place Early:

  - Infrastructure - who? (roads, towns, etc.)
  - General Technical Scheme fixed early
  - Labour Stability
  - Benefits to Canada - what they are and their effectiveness
  - Foreign Investment Rules changed
  - Rules re Resource Use and Environment - negotiated and understood

- Have opportunity to negotiate "rules" on resource use and environment early - employ practical technology.

- Recognize Risk - Assess Risk:

  - early payout
  - recognize efficiency reward

- - - - - - - - - - - -

- Fiscal Responsibility by Government:

  - stable and flexible
  - tax system based on profit

- Oilsand Declared a National Resource

- Lack of Cooperation and Coordination:

  - private sector/government

- Marketing of Syncrude:

  - Relate to world supply/demand situation

- Regulations should be based on available technology and detailed analysis of the impact by regulations.

- - - - - - - - - - - -

- Acceptable Project Economics - Investor Confidence

- Stable Product Value

- Stable Government Criteria:

  - environmental
  - profit
  - resource utilization

- Reliable Plant Design:

  - ore body
  - technology
  - production required
  - operating costs
  - safety

- Construction and Operational Stability:

  - personnel and management

- - - - - - - - - - - -

- Scale:

  - smaller size, consider revenue redistribution

- Early Revenue Generation

- Ownership and Structure:

  - recognizing the type (mine and upgrading, etc.) of facilities

- Transportation Elements:

  - integration from an energy viewpoint

- Establish "One Window" Approach to Governments in dealing with Non-commercial Terms; i.e.:

  - labour planning
  - regional/industrial benefits

- Cost/Benefit/Risk Aspects of Resource Utilization and Environmental Considerations

- - - - - - - - - - - - -

- Reduce Risk from Political Sources:

  - long-term strategy for oilsands development

- Early Incremental Approval Process for Development

- Government Feature Authority Linked to Responsibility

- Clear Guidelines for Commercial Terms:

  - early
  - long-term
  - flexible
  - provide attractive return
  - reward all levels of improvement

- Development Scheme that Optimizes Resources Development:

  - Optimum (Mining Upgrading)
    (Process Separation)

- Address Technical/Operational Reliability

  - predictable construction and operating costs
  - predictable sustainable production

- Economic Viability - Relating to Time and Each Other:
  - capital cost
  - operating cost
  - product price
  - taxes and royalties

  Based on return and payout.

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Discussion of the points listed, and the approach to be used for Tasks 3 and 4 (Topic 12) occupied the remainder of the morning.

12. It was decided that three such groups would be established for the purpose of:

- Developing a preliminary list of "Musts" and "Wants" (Task 3)
- Determining whether the Kepner-Tregoe or some other structured approach is the preferred methodology to use in examining and evaluating alternate schemes.

The make-up of the groups was as follows:

Group #1	Group #2	Group #3
Jim Guthrie (leader)	Tom McCann (leader)	Morris McClement (leader)
Fred Callaway	Jim Abbott	Al Hyndman
Ken Clarke	Andy Blair	Doug Kim
John Porteous	Dave Devenny	Gerry Lewis-Steer
Bob Wrubleski	John Filby	Dave Rose
		Paul White

- LUNCH BREAK -

Following lunch, the participants split into the three groups and addressed the tasks as developed before lunch.

Near the end of the day two groups reconvened to present and discuss results of individual sessions. These presentations continued into the following day. The preliminary listing of "Musts" and "Wants" as developed by the three groups follow:

A) Group #1 - Jim Guthrie

Decision Statement

Find the best ways of developing Surface Mineable Oil Sands Plants.

Musts

Owners - Receive greater than utility rate of return.
Federal Government - Receive an acceptable benefit/cost ratio.
Provincial Government - Receive an acceptable benefit/cost ratio.

Project Non-controllable Factors

(May be capable of being influenced)

Royalties
Taxes
Product Prices
Environmental Regulations
Socio-Economic Constraints
Regional & Canadian Benefits
Resource Utilization
Regulatory Process
Availability of Financing
FIRA
Access to Markets (Priority)
Capacity of - Canadian Manufacturers
- Engineering Contractors
- Labour
Technology
Infrastructure
Labour Stability

Wants

Minimum Payout Time
Minimum Upfront Capital
Maximum R.O.I.
Minimum Prototyping
Achievable Production Time
Minimize Scale-up

- - - - - - - - - - - - - - - - - -

Early Regulatory Approval

Stable Commercial Regime
Flexible Commercial Regime

- -

Amenable to Modularized Expansion Labour Plan
Minimum Time to Production
Minimum Site Area
Minimum Site Fabrication

- -

Renegotiate Guidelines < Policies / Regulations

- -

Minimum disruption to social structure
Minimum adverse disruption to local economy

- - - - - - - - - - - -

Maximize Safety
Maximize Weather Insensitivity
Maximize Operational Simplicity
Minimum Operating Labour
Minimum Downtime
Amenable to On-stream Maintenance
Amenable to Wide Range of Ore Feed Quality
Minimal Environmental Impact
High Liquid Yield
High Bitumen Recovery
High Net Energy Recovery
Minimum Tailings Ponds

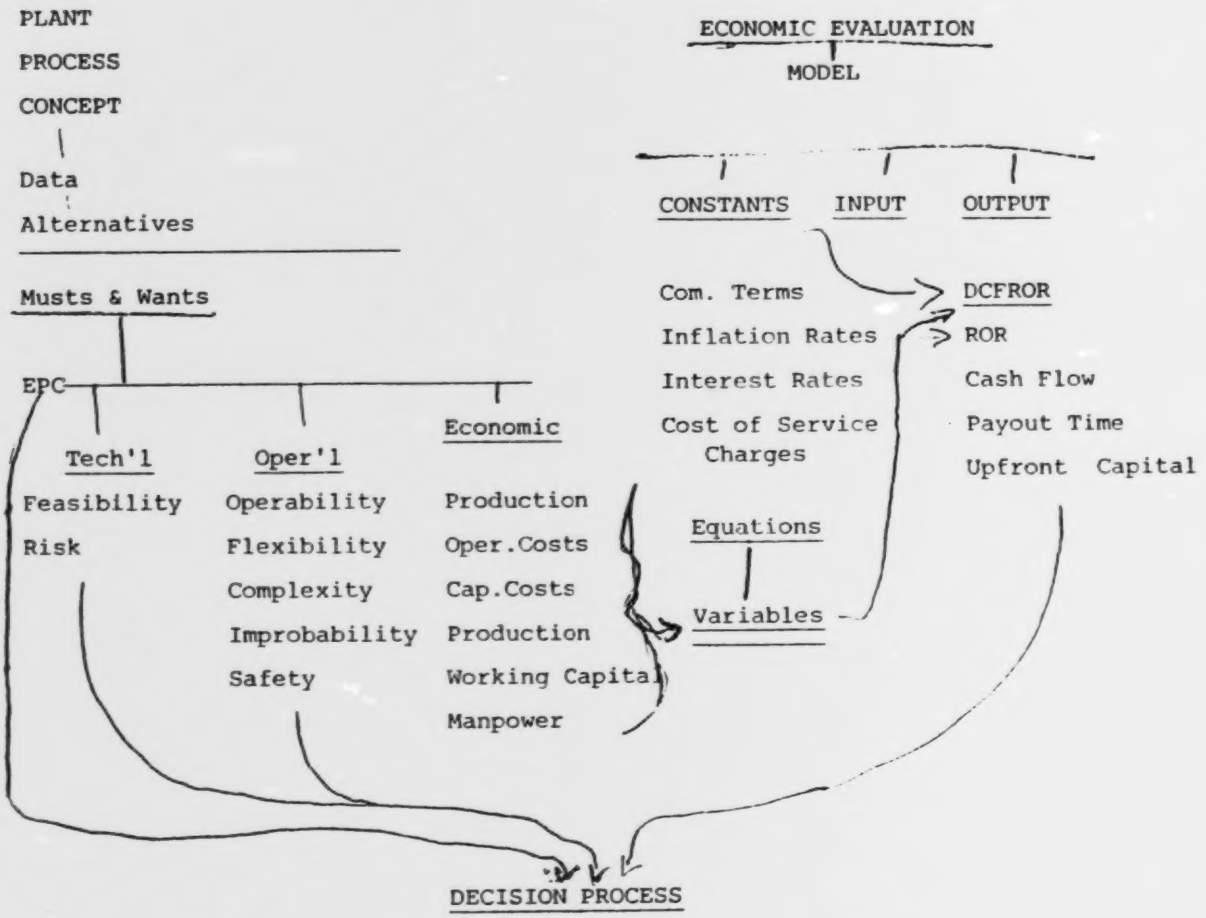
- - - - - - - - - - - -

Amenable to Selective Mining of Ore Body

Adaptability to Variations in Mine
(Flexible to) Conditions
(Mobility)

Minimal Haul Distance
Amenable to Small Scale Concept
Minimum Capital Cost/(Barrel)

- - - - - - - - - - - -



PLANT
PROCESS
CONCEPT

Data
Alternatives

Musts & Wants

EPC

Tech'l
- Feasibility
- Risk

Oper'l
- Operability
- Flexibility
- Complexity
- Improbability
- Safety

Economic
- Production
- Oper.Costs
- Cap.Costs
- Production
- Working Capital
- Manpower

ECONOMIC EVALUATION
MODEL

CONSTANTS
- Com. Terms
- Inflation Rates
- Interest Rates
- Cost of Service Charges

INPUT

OUTPUT
- DCFROR
- ROR
- Cash Flow
- Payout Time
- Upfront Capital

Equations

Variables

DECISION PROCESS

K.T. ANALYSIS

- Ranking of Alternates
- Other Alternates
- Area of further study
- Directions of Future Work
- Interaction

The group had also addressed themselves to a proposed approach for developing the "Musts" and "Wants" and dealing with the decision making process. This is schematically depicted on Page 103.

B) Group #2 - Tom McCann

In Order to Encourage Tarsands Development

Investor Confidence must be Increased

A long-term strategy for tarsands development should be promulgated

The rules of the game should be identified and understood early:

- Commercial Terms
- Approval Process
- Environmental Controls
- Resource Utilization
- Infrastructure

Controllable Risks must be Minimized

Musts

Meet Controlling Environment Regulations
Have Reserves
Market for Product

Decision Statements

Choose Best Surface Mineable Scheme(s) in the 1980's
Identify Best Business Climate (external) for Development to Proceed

Wants

Technical

Minimum Complexity
Minimum Technical Risk
Maximum Reliability
Minimum Plant Infrastructure
Minimum External Infrastructure
Earliest Possible Startup

Minimum Management Costs < Construction
Operation

Maximum Yield
Maximum Product Quality
Maximum Delinquentability
Maximum Ease of Operation
Minimum Startup Time
Maximum Service Factor
Minimum Environmental Impact
Maximum Expandability
Maximum Flexibility
Maximum Adaptability to New Technology

Minimum Weather Effects < Construction
Operation

Optimum Balance between Systems

Economic

Minimum Capital Cost = (Capital)
(+ Inflation)
(+ Interest)

Minimum Sustaining Capital
Minimum Operating Cost
Minimum Cost/Barrel
Earliest Possible Startup

Minimum Management Cost < Construction
Operation

Maximum Rate of Return to Operator
Minimum Payback Period

Minimum Economic Risk (Capital
(Operation
(Revenue
(Time

Intangibles
Incentives for Improvement

Business

Labour Supply Planning
Government Incentives for Training and Industrial Development
Freedom to Develop Reserve in Most Economic Manner; e.g., Arbitrary Cutoffs
Methods and Timing of Reclamation

Define at Beginning:

- Infrastructure
- Sponsors/Builders: Ground Rules for Separated Facilities

Pre-project Coordination of Government Interfaces

Access to Foreign Markets
Maximum Product Price
Maximum Available Trained Labour Pool
Incentives for Improvement
Early Setting of Commercial Terms
Flexibility in Commercial Terms to Insure Continuing Return to Operator
Early Incremental Approval
Maximum Canadian Content
Aid Canadian Technical Talent Pool

Economic/Technical Intangibles

Maximum Canadian Benefits

Minimum Society Adverse Impact:
- Pressure Groups
- Regional - Housing and Staff-related
- Training

Other Considerations

The Regulatory Process be Greatly Simplified and Rationalized
Should Adopt a Long-term Approach to Developing Skilled Labour Supply

Power Utilization
- Transportation of Products and Utilities

- - - - - - - - - - - - - -

(C) Group #3 - Morris McClement

This group had not completed their deliberations and, therefore, were not in a position to be as specific as the other two groups. Morris outlined the approach they were taking and the conclusions they were reaching regarding "Musts" and "Wants".

They had elected to approach the List of Objectives, by categorizing into three groups: 1) those which the project could directly control such as schedule, costs, technology; 2) those which the project could not control, but might be able to influence, such as royalties, prices; and 3) those beyond the project's ability to control or influence, such as inflation, world crude prices.

The Concept Development Team then decided that the entire group should spend some time developing the "Musts" and a "long" list of "Wants".

The preliminary "Musts" and "Wants" of each of the three sub-groups were next discussed in considerable detail. The "Musts" were addressed and the group concluded that the "Musts" options to be considered were:

1. No "Musts"
2. Project must yield a DCROI of 22% or a Real Rate of 11-1/2%.
3. A business/Project Development/Project Execution/Project Operating Environment that provides a framework for the development of tarsands, provides an acceptable return to the developers commensurate with the risks, and permits and facilitates effective project execution and operation.
4. Owners must receive a greater-than-utility rate of return, plus both senior levels of government must have a satisfactory cost/benefit situation.
5. In evaluating and selecting the best scheme, there are no specific "Musts" to be taken into account. In order for the best scheme to proceed, the conditions described in "3" above must be put in place.
6. Must (a) Meet Controlling Environment Regulations, (b) Have Reserves and (c) Have a Market for Product.

Statement "5" was finally selected by the group as the most appropriate of the selected "Musts" options and this will be developed more fully and written up by Techman for consideration by the Concept Development Team.

It was agreed that (2) and (3) above will be included in the "Wants" statement and accompanying writeup.

The group then developed a long list of "Wants" which is included below:

"WANTS"

- TECHNOLOGICAL RISK (MINIMIZE)
    - Maximum Proven Technology
    - Scale-up
    - Prototyping (Maturity)
    - Applicability
    - Licensor Back-up
    - Quality

- MAXIMIZE OPERABILITY
  - Safety/Hygiene
  - Complexity - Systems
    - Operational
  - Integration
  - Diversity/Redundancy
  - Flexibility
  - Steam Factor
  - Start-up (ease of, time to achieve, production)
  - Maintainability
  - Weather Insensitivity
  - Operating Continuity
  - Performance re Feed Variability
  - Process/Operational Stability
  - Vulnerability to Upsets

- OPTIMIZE PRODUCT(S) QUALITY TO MEET MARKET NEED

- NATURAL RESOURCE UTILIZATION (MAXIMIZE)
  - Net Value of Product/BBL Mineable Ore Body

- MINIMIZE ADVERSE ENVIRONMENTAL IMPACT
  - Air
  - Water (surface/groundwater)
  - Hydrocarbon Releases
  - Water Withdrawal
  - Tailings
  - Waste Disposal

- MINIMIZE ADVERSE SOCIO-ECONOMIC IMPACT
  - Minimum Peaking - Labour
    - Manufacturing
  - Maximize Ongoing Activity
  - Create Entrepreneur & Employment Opportunities for Indigenous Population

- MINIMIZE PROJECT SUPPLIED INFRASTRUCTURE AT THE SITE
  - Housing
  - Other

- ABILITY TO EXPAND (SERIES/PARALLEL)
  - To Preserve Options
    - To Enhance Capacity
    - Quality
    - Efficiency
    - New Technology
  - Lower Initial Costs
  - Lower Manpower for Start-up (Gradual Build-up)
  - Less likely to overheat economically
  - More likely to be financable
  - Quicker government approvals

- MINIMUM TIME TO CASH FLOW

- MAXIMUM DCF ROR

- MINIMIZE INITIAL COST

- MAXIMIZE N.P.V.

- MINIMIZE SUSTAINING CAPITAL

- MINIMIZE OPERATING COST

- MAXIMIZE REVENUE/OPERATING COST

- MINIMIZE UNIT COSTS (CAPITAL, OPERATING, SUSTAINING CAPITAL)

- FINANCIALLY COMPATIBLE/STABLE OWNERS
  - Simplified Ownership Structures
  - Minimize Numbers
  - Minimize Types of Owners

- MAXIMIZE CANADIAN & REGIONAL BENEFITS
  - Employment Opportunities
    - Labour
    - Technical
    - Manufacturing
  - Export Opportunities
  - Development of Skills
  - Add to Tax Pool
  - Contribute to Energy Self-sufficiency
  - Balance of Payments
  - Native Employment
  - Native Business Opportunities

It was then decided that the three sub-groups would assemble the next morning, October 15th, to reduce the long list of "Wants" into approximately 8 to 12 items with Ranks and Weightings for use in a Kepner-Tregoe analysis of cases.

"END OF DAY"

Next morning the three sub-groups met to each develop their own list of "Wants" including ranking and weighting in a format appropriate to Kepner-Tregoe case analysis. The starting point was the long list of wants developed by the entire Concept Development Team, as previously identified.

The three groups then convened to compare results, which are summarized below:

Group #1 - Jim Guthrie

Item	Rank	Weight
Minimize Technological Risk	4	8
Maximize Operability	2	9
Maximize Resource Utilization	7	5
Minimize Adverse Environmental Impact	8	4
Minimize Adverse Socio-Economic Impact	9	3
Maximize Expandability	6	5
Minimize Time to Cash Flow	5	7
Maximize DCF ROR	1	10
Minimize Initial Cost	3	7
Maximize Canadian & Regional Benefits	10	2

Group #2 - Tom McCann

Item	Rank	Weight
Maximize Return	1	10
Minimize Technological Risk	2	10
Minimize Financial Exposure	3	9
Maximize Operability	4	9
Maximize Operating Revenue	5	8
Maximize Ability to Expand	6	7
Minimize Adverse Environmental Impact	7	6
Maximize Natural Resource Utilization	8	5
Maximize Product Quality	9	4
Maximize Canadian Benefits	10	3
Minimize Adverse Socio-Economical Impacts	11	2
Minimize Ownership Challenges	12	1

Group #3 - Morris McClement

Item	Rank	Weight
Economic Performance & Risk	1	10
- DCF ROR		
- NPV		
- Time to Cash Flow		
- Initial Capital Cost		
Financability	5	3
Technological Considerations & Risk	3	6
Operability	2	7
Socio-Economic Impact & Benefits	7	2
Environmental Impact/Resource Utilization	6	3
Administrative Complexity	4	4
- Ownership/Structure		
- Infrastructure Considerations		
- Compatibility of Owners		
- Similarity of types of Owners		

Although the three groups had approached the problem in different ways, the results were quite similar.

- LUNCH BREAK -

After lunch the entire group, working from the above three lists, developed the following listing of "Wants" (Objectives).

- Minimize Technical Risk
- Maximize Expandability
- Maximize Operability
- Minimize Financial Exposure
- Maximize Financial Performance
- Minimize Adverse Environmental Impact
- Minimize Adverse Socio-Economic Impact
- Optimum Utilization of Natural Resources
- Minimize Administrative Complexity
- Maximize Canadian Benefits

The three sub-groups then met separately to Rank and Weight the above ten "Wants".

When the three sub-groups re-assembled into the main group, ranking and weighting was developed. This appears below:

Item	Rank	Weight
Financial Performance	1	10
Minimum Financial Exposure	2	9
Minimum Technical Risk	3	8
Maximum Operability	4	8
Maximum Expandability	5	4
Optimum Natural Resource Utilization	6	4
Minimum Environmental Impact	7	4
Minimum Administrative Complexity	8	4
Minimum Adverse Socio-Economic Impacts	9	2
Maximum Canadian Benefits	10	2

Techman personnel tabled preliminary drafts of Proposed Representative Geology for consideration by the group. This will be further developed and used as a basis for development of Mining Schemes.

Dave Devenny handed out copies of vugraphs entitled:

AWARENESS PRESENTATION

OIL SANDS DEMONSTRATION CENTRE

INCENTIVES FOR INDUSTRIAL PARTICIPATION

Dave covered the highlights of the material. A copy of this hand-out is attached.

The group will resume deliberations the week of October 25, 1982 starting at 9:00 A.M., on Monday, October 25th.

"END OF DAY"

DEVENNY HANDOUT

AWARENESS PRESENTATION

OIL SANDS DEMONSTRATION CENTRE

INCENTIVES FOR INDUSTRIAL PARTICIPATION

BACKGROUND

NEED: DEMONSTRATION SCALE TESTING

CONCEPT: TEST CENTRE
JOINT EFFORT - INDUSTRY AND GOVERNMENT
SHARE COSTS
FACILITATE DEVELOPMENT

STUDY: SCOPED PROJECT
CONCEPT VALID
REVEALED INDUSTRY "PROBLEMS"

PURPOSE OF THIS PRESENTATION

TO PROGRESS DEMONSTRATION SCALE TESTING AND APPLICATION OF NEW TECHNOLOGY.

HEALTH IN THE OIL SANDS INDUSTRY IS AN ESSENTIAL CONSIDERATION.

NEED TO LOOK AT INCENTIVES FOR INDUSTRIAL PARTICIPATION.

STEPS

I. MOTIVATION FOR INDUSTRY.

II. CHARACTERISTICS OF OIL SANDS DEVELOPMENT.

III. CHARACTERISTICS OF DEMONSTRATION SCALE TESTING AND APPLICATION.

I. MOTIVATION FOR INDUSTRY

- PROFIT ORIENTED.
- INVEST IN ANTICIPATION OF RETURN.
- HIGHER RISK - HIGHER RETURN REQUIRED.
- RETURN FOR OIL SANDS DEVELOPMENT.
    - SUCCESSFUL, PROFITABLE OPERATION OF A COMMERCIAL OIL SANDS PLANT.

II. CHARACTERISTICS OF OIL SANDS DEVELOPMENT

1. TIME:

- MANY YEARS INVOLVED IN DEVELOPMENT.
- INCREASING COSTS WITH EACH PHASE.
- MANY YEARS TO RETURN FROM COMMERCIAL PRODUCTION.
- DIFFERS FROM CONVENTIONAL OIL

(SEE FIGURE 2)

II. CHARACTERISTICS OF OIL SANDS DEVELOPMENT

2. CYCLICAL:

- HISTORIC UPS AND DOWNS.
- DOWN CYCLES SLOW DEVELOPMENT.
- TRENDS INDICATED BY FIGURE 1.

II. CHARACTERISTICS OF OIL SANDS DEVELOPMENT

3. DEVELOPMENT COSTS:

- EXPENSIVE.
- COST TO APPLICATION STAGE $50 TO $100 MILLION.
- LONG TIME INCREASES COST (TIME VALUE OF MONEY)

II. CHARACTERISTICS OF OIL SANDS DEVELOPMENT

4. APPROVAL PROCESS:

- APPROVAL FOR DEVELOPMENT IS LATE.
  - AFTER YEARS OF WORK.
  - AFTER EXPENDITURE OF $50 - $100 MILLION.
- EARLIER APPROVAL DESIRED.

(SEE FIGURE 2 AND FIGURE 4)

II. CHARACTERISTICS OF OIL SANDS DEVELOPMENT

5. ACHIEVING FULL PRODUCTION:

- RETURN FROM COMMERCIAL PRODUCTION.
- PLANTS TO DATE "SLOW STARTERS".

  (SEE FIGURE 3)
- DELAY IN REACHING FULL PRODUCTION DECREASES RETURN.
- "NEW TECHNOLOGY" INTRODUCES CONCERN RE START-UP AND PROFITABILITY.

II. CHARACTERISTICS OF OIL SANDS DEVELOPMENT

6. COMMERCIAL TERMS:

- HISTORICALLY - SET AFTER APPROVAL.

  * LATE *

- PROJECTED INCOME FROM AN EXISTING PLANT SHOWN IN FIGURE 7.

- DOES NOT ADDRESS RETURN FOR DEMONSTRATION SCALE TESTING AND APPLICATION.

- MORE FAVOURABLE TERMS UNDER CONSIDERATION.

II. CHARACTERISTICS OF OIL SANDS DEVELOPMENT

7. CASH FLOW:

- OIL SAND DEVELOPMENT IS EXPENSIVE.
- LONG TIME TO RETURN ON INVESTMENT.
- NEED CASH FLOW FROM OTHER OPERATIONS.
- CASH FLOW IN INDUSTRY IS LIMITED.
- LOW CASH FLOW - LIMITS DEVELOPMENT.

II. CHARACTERISTICS OF OIL SANDS DEVELOPMENT

SUMMARY OF KEY POINTS

1. INDUSTRY IS PROFIT MOTIVATED.
2. RETURN COMES FROM COMMERCIAL PRODUCTION.
3. MANY YEARS - DECADES.
4. CYCLICAL INTERRUPTIONS.
5. DEVELOPMENT EXPENSIVE.
6. APPROVAL LATE!
7. ACHIEVING FULL COMMERCIAL PRODUCTION SLOW.
8. COMMERCIAL TERMS ESTABLISHED LATE!
9. COMMERCIAL TERMS AT EXISTING PLANTS DO NOT ADDRESS RETURN NEEDED FOR DEMONSTRATION TESTING AND APPLICATION.
10. MORE FAVOURABLE TERMS ARE BEING EXPLORED.
11. HEALTHY CASH FLOW IN INDUSTRY NEEDED TO SUPPORT OIL SAND DEVELOPMENT.

III. CHARACTERISTICS OF DEMONSTRATION TESTING AND APPLICATION

1. CHARACTERISTICS: (TABLE 1)

- STAGES OF NEW PROCESS DEVELOPMENT.
- CORRELATION OF PROJECT AND PROCESS DEVELOPMENT.

(SEE FIGURE 9)

III. CHARACTERISTICS OF DEMONSTRATION TESTING AND APPLICATION

2. COST IMPLICATIONS:

- DEMONSTRATION TESTING IS EXPENSIVE.
- EFFECT ON PROJECT DEVELOPMENT COST.
  (SEE FIGURE 7)
- POTENTIAL TO DELAY ACHIEVING COMMERICAL PRODUCTION.
- COST INCREASE MUST BE BALANCED BY INCREASED RETURN FROM COMMERCIAL PRODUCTION.

III. CHARACTERISTICS OF DEMONSTRATION TESTING AND APPLICATION

3. TIMING:

- HIGH COST.
- JUSTIFICATION REQUIRES TIMELY INVESTMENT.
- TEST JUST BEFORE USE.
- REQUIRE 2+ YEARS TO DESIGN
  BUILD
  OPERATE
  EVALUATE.
- REQUIRE EVALUATION BEFORE DESIGN/CONSTRUCTION.

III. CHARACTERISTICS OF DEMONSTRATION TESTING AND APPLICATION

4. TIMING OF APPROVAL:

TO JUSTIFY MAJOR INVESTMENT (E.G. DEMO TEST),

INDUSTRY DESIRES:

- IDENTIFIED PROJECT.
- APPROVAL FOR COMMERCIAL DEVELOPMENT.
- COMMERCIAL TERMS IN PLACE.

PRESENT TIMING OF APPROVAL AND DEFINING COMMERCIAL TERMS IS INCOMPATIBLE WITH ABOVE NEEDS:

- TOO LATE.
- NO TIME FOR DEMONSTRATION TESTING (WITHOUT DELAYING THE PROJECT).

NEED EARLIER:

- PROJECT APPROVAL:
- DEFINITION OF COMMERCIAL TERMS.

III. CHARACTERISTICS OF DEMONSTRATION TESTING AND APPLICATION

5. COMMERCIAL TERMS:

- COMMERCIAL TERMS AT EXISTING PLANTS DO NOT RECOGNIZE RETURN NEEDED TO JUSTIFY DEMONSTRATION TESTING OR APPLICATION OF NEW TECHNOLOGY.
- MORE FAVOURABLE TERMS UNDER DISCUSSION.
- CONSIDERATIONS:
  - REDUCED TAX AND ROYALTY FOR THE COMMERCIAL OPERATION.
  - ACCELERATED WRITE-OFF FOR RESEARCH AND DEVELOPMENT.
  - APPLY DEMONSTRATION COSTS TO OTHER EXPENSES:
    - LEASE RENTALS,
    - WORK REQUIREMENTS.
  - APPLY DEMONSTRATION COSTS TO FUTURE ROYALTIES.
  - DEVELOP "FENCED PROFITS" FOR OIL SANDS DEVELOPMENT.

III. CHARACTERISTICS OF DEMONSTRATION TESTING AND APPLICATION

6. CASH FLOW:

- HEALTHY CASH FLOW NEEDED TO PAY FOR DEMONSTRATION TESTING AND APPLICATION OF NEW TECHNOLOGY.

- LIMITED CASH FLOW LIMITS POTENTIAL FOR DEMONSTRATION TESTING AND APPLICATION OF NEW TECHNOLOGY.

III. CHARACTERISTICS OF DEMONSTRATION TESTING AND APPLICATION

SUMMARY OF KEY POINTS

1. DEMONSTRATION TESTING IS EXPENSIVE.

2. COULD
   - DOUBLE PROJECT DEVELOPMENT COST,
   - DELAY ACHIEVING FULL PRODUCTION.

3. TIMING IMPORTANT:
   - EARLY ENOUGH FOR INCLUSION IN A PROJECT.
   - LATE ENOUGH TO MINIMIZE COST.

4. INCOMPATABILITY IN TIMING:
   - INDUSTRY NEEDS PROJECT APPROVAL AND COMMERCIAL TERMS IN PLACE BEFORE TESTING CAN BE JUSTIFIED.
   - PRESENT TIMING DOES NOT ALLOW TESTING WITHOUT DELAYING PROJECT.
   - EARLIER APPROVAL AND DEFINITION OF COMMERCIAL TERMS NEEDED.

5. COMMERCIAL TERMS APPLIED TO EXISTING PLANTS NOT STRUCTURED TO COPE WITH COST AND RISK INVOLVED. MORE FAVOURABLE TERMS ARE NEEDED - AND ARE BEING EXPLORED.

6. A LOW CASH FLOW IN INDUSTRY DECREASES THE POTENTIAL TO SUPPORT DEMONSTRATION TESTING AND APPLICATION OF NEW TECHNOLOGY.

IV. HIGHLIGHTS

1. CONCEPT OF A DEMONSTRATION CENTRE IS VALID.
    - JOINT EFFORT - GOVERNMENT/INDUSTRY.
    - REDUCE COSTS VIA THE CORE FACILITY.
    - REDUCE TIME TO ACTIVATE.
2. EXISTENCE OF A DEMONSTRATION TEST FACILITY WILL FACILITATE AND ENHANCE DEVELOPMENT OF NEW TECHNOLOGY.
3. INDUSTRIAL PARTICIPATION IS HIGHLY DESIRABLE.
4. NEED TO IDENTIFY INCENTIVES FOR INDUSTRIAL PARTICIPATION AS HEALTH IN INDUSTRY IS AN IMPORTANT PART OF TECHNOLOGY DEVELOPMENT AND APPLICATION.

IV. HIGHLIGHTS

REVIEW

- MOTIVATION FOR INDUSTRY
- CHARACTERISTICS OF OIL SANDS DEVELOPMENT
- CHARACTERISTICS OF DEMONSTRATION TESTING AND APPLICATION

IV. HIGHLIGHTS

CRITICAL AREAS

WHERE CHANGE IS NEEDED:

1. TIMING OF PROJECT APPROVAL.
2. TIMING OF DEFINITION OF COMMERCIAL TERMS.
3. COMMERCIAL TERMS NEED TO PROVIDE INCENTIVE FOR DEVELOPMENT, DEMONSTRATION TESTING (IF WARRANTED) AND APPLICATION OF BETTER TECHNOLOGY.

V. ACTION

THIS IS AN AWARENESS PRESENTATION.

IDENTIFY PROBLEMS AFFECTING INDUSTRIAL PARTICIPATION IN DEMONSTRATION SCALE TESTING AND UTILIZATION OF NEW TECHNOLOGY.

CURE - RE APPROVAL PROCESS AND COMMERCIAL TERMS IS LEFT TO THOSE WITH RESPONSIBILITY IN THIS AREA.

ACTION HOPED FROM AOSTRA.

1. UNDERSTAND THE NEED FOR INDUSTRIAL PARTICIPATION AND THE CONCERNS RAISED.
2. ENDORSE THE CONCEPTS RAISED.
3. SUGGEST HOW TO IMPROVE INCENTIVES FOR INDUSTRIAL PARTICIPATION.

TABLE 1

STAGES OF DEVELOPMENT - REVOLUTIONARY EXTRACTION PROCESS

	TYPICAL ACTIVITY	APPROXIMATE COST (M = MILLION)	CORRESPONDING PHASE (COMMERCIAL PLANT)
CONCEPT STAGE	DEVELOP CONCEPTS BENCH SCALE RESEARCH	—	EXPLORATION
EARLY PILOT STAGE	SMALL PILOT TESTS DESIGN CONCEPTS ECONOMIC EVALUATION	$1M	EXPLORATION AND EARLY CONCEPTUAL DESIGN
LATE PILOT STAGE	LARGE SCALE PILOT TESTS ECONOMIC EVALUATION	$10M	EARLY CONCEPTUAL DESIGN
PROVE COMMERCIAL APPLICATION	DEMONSTRATION TESTS DETAILED DESIGN DETAILED ECONOMIC EVALUATION	$100M	— AFTER COMMERCIAL TERMS IDENTIFIED (EARLIER DEFINATION DESIRABLE) — EARLY DETAILED
OPERATIONS SUPPORT	REFINE OPERATIONS TROUBLE SHOOT	—	CONSTRUCTION AND OPERATIONS

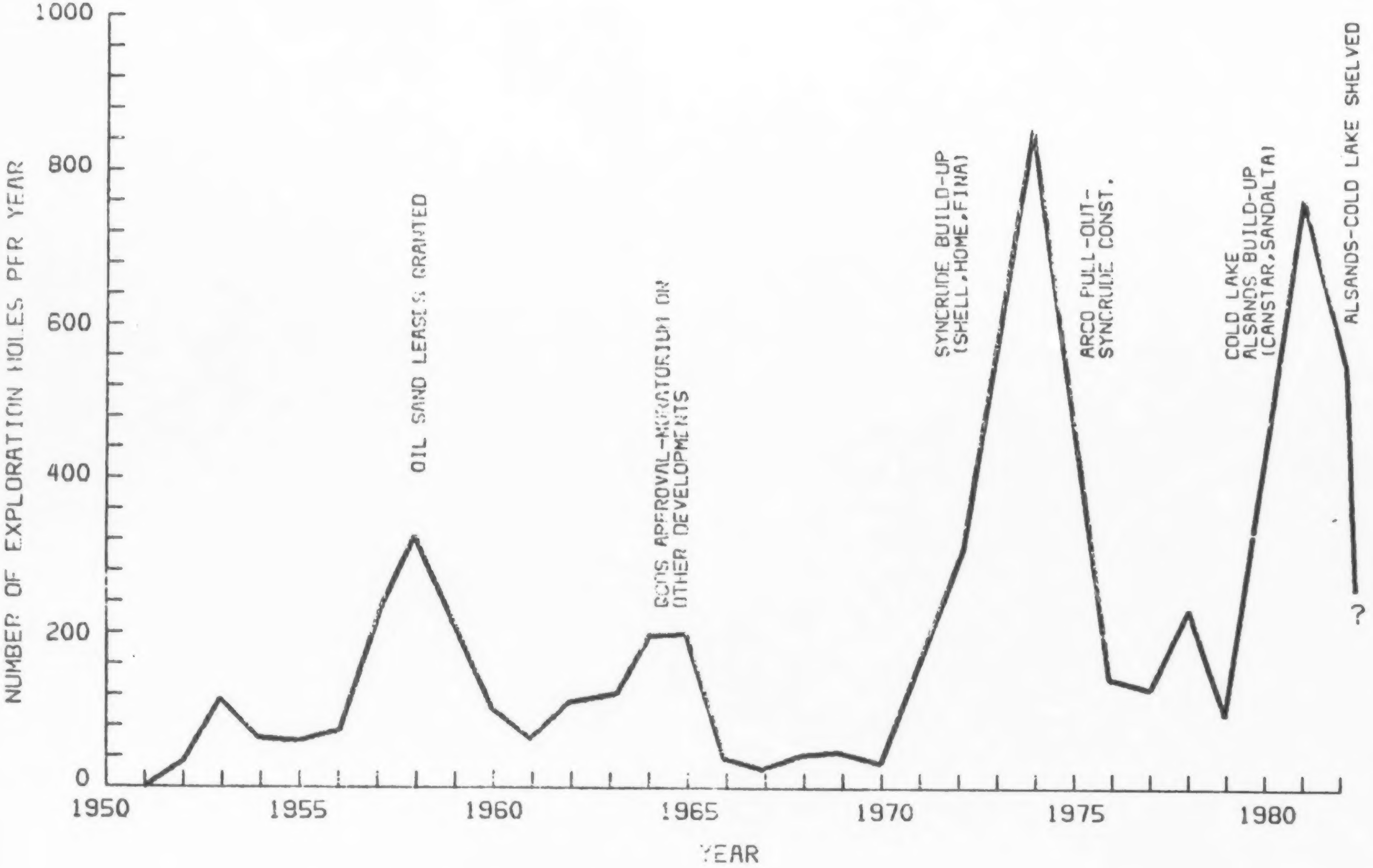


FIGURE 1 EXPLORATION ACTIVITY IN OIL SANDS

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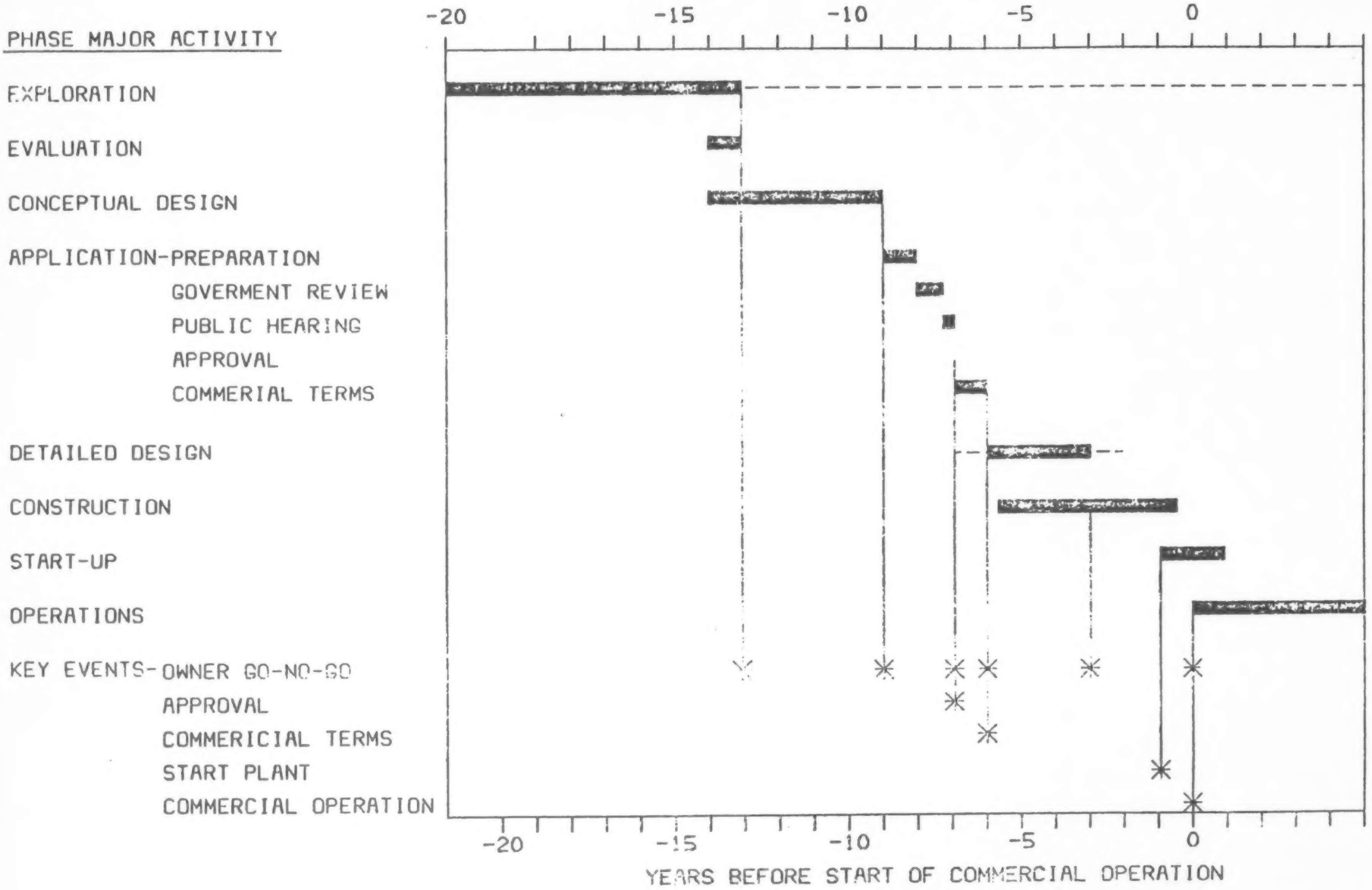

FIGURE 2 TIMING OF A TYPICAL OIL SANDS MEGA PROJECT

1072GA

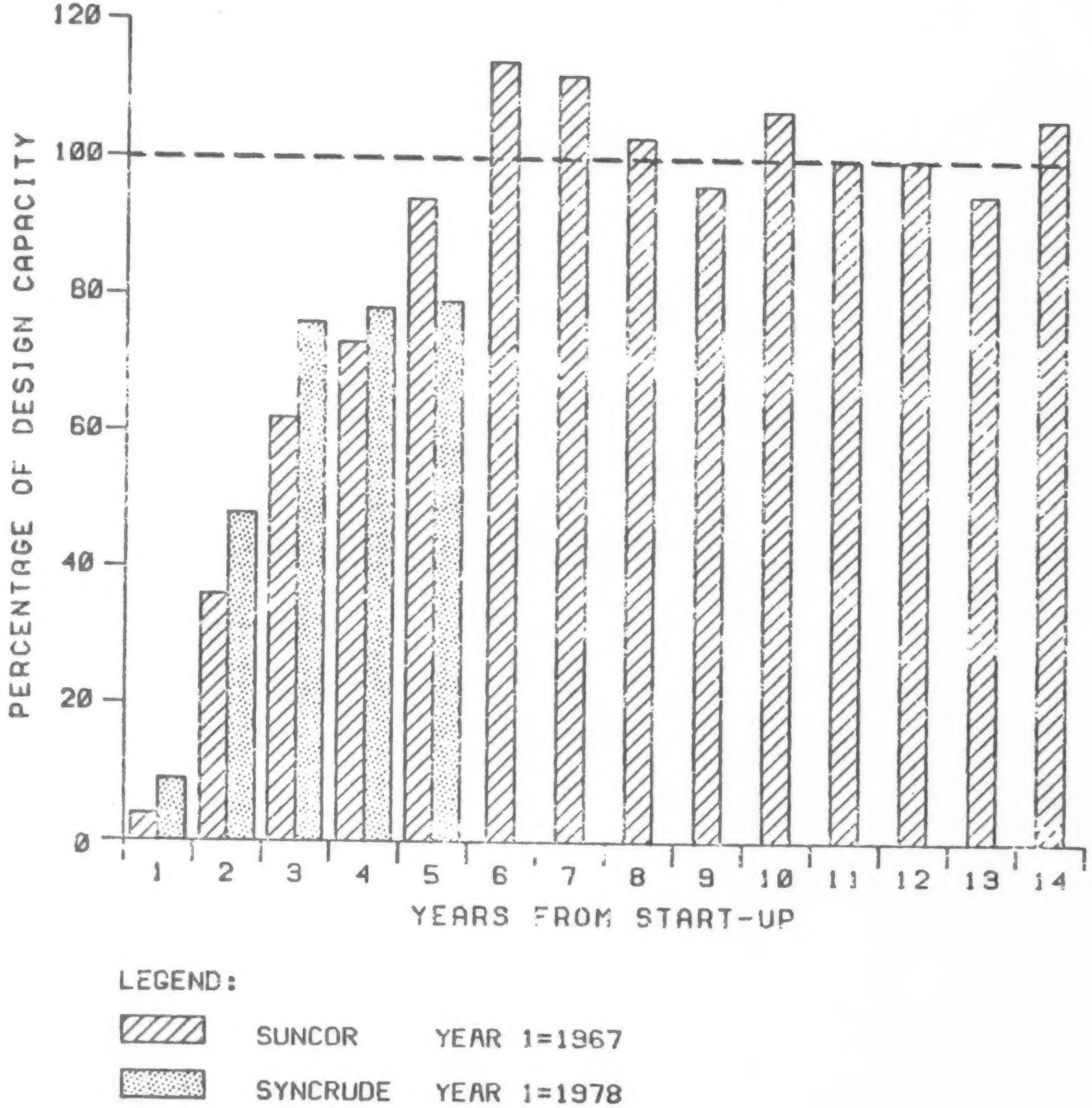

FIG. 3 - PRODUCTION HISTORY OF EXISTING OIL SANDS PLANTS

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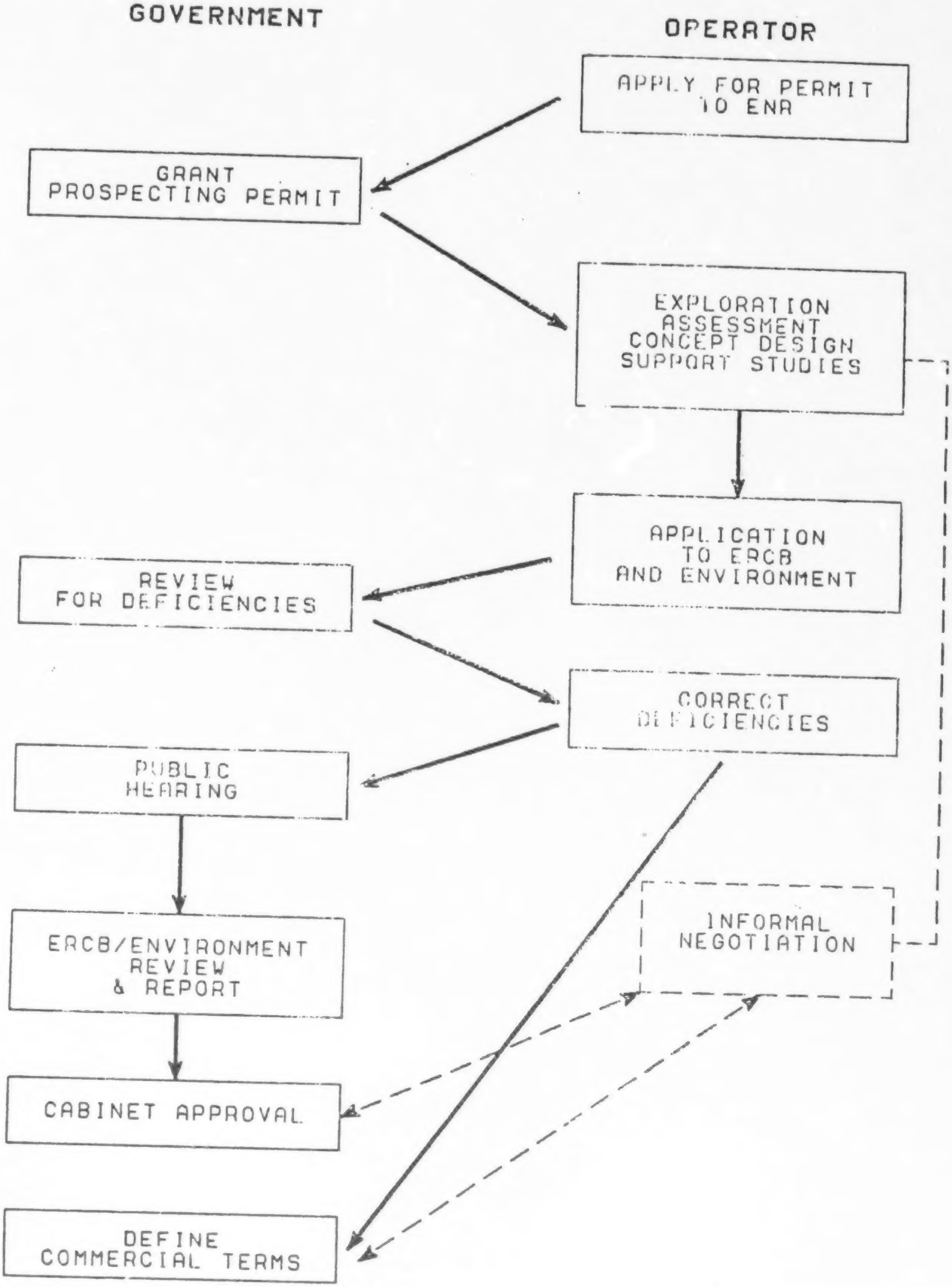
GOVERNMENT
OPERATOR
APPLY FOR PERMIT TO ENR
GRANT PROSPECTING PERMIT
EXPLORATION ASSESSMENT CONCEPT DESIGN SUPPORT STUDIES
APPLICATION TO ERCB AND ENVIRONMENT
REVIEW FOR DEFICIENCIES
CORRECT DEFICIENCIES
PUBLIC HEARING
INFORMAL NEGOTIATION
ERCB/ENVIRONMENT REVIEW & REPORT
CABINET APPROVAL
DEFINE COMMERCIAL TERMS

FIG.4 - REGULATORY APPROVAL PROCESS

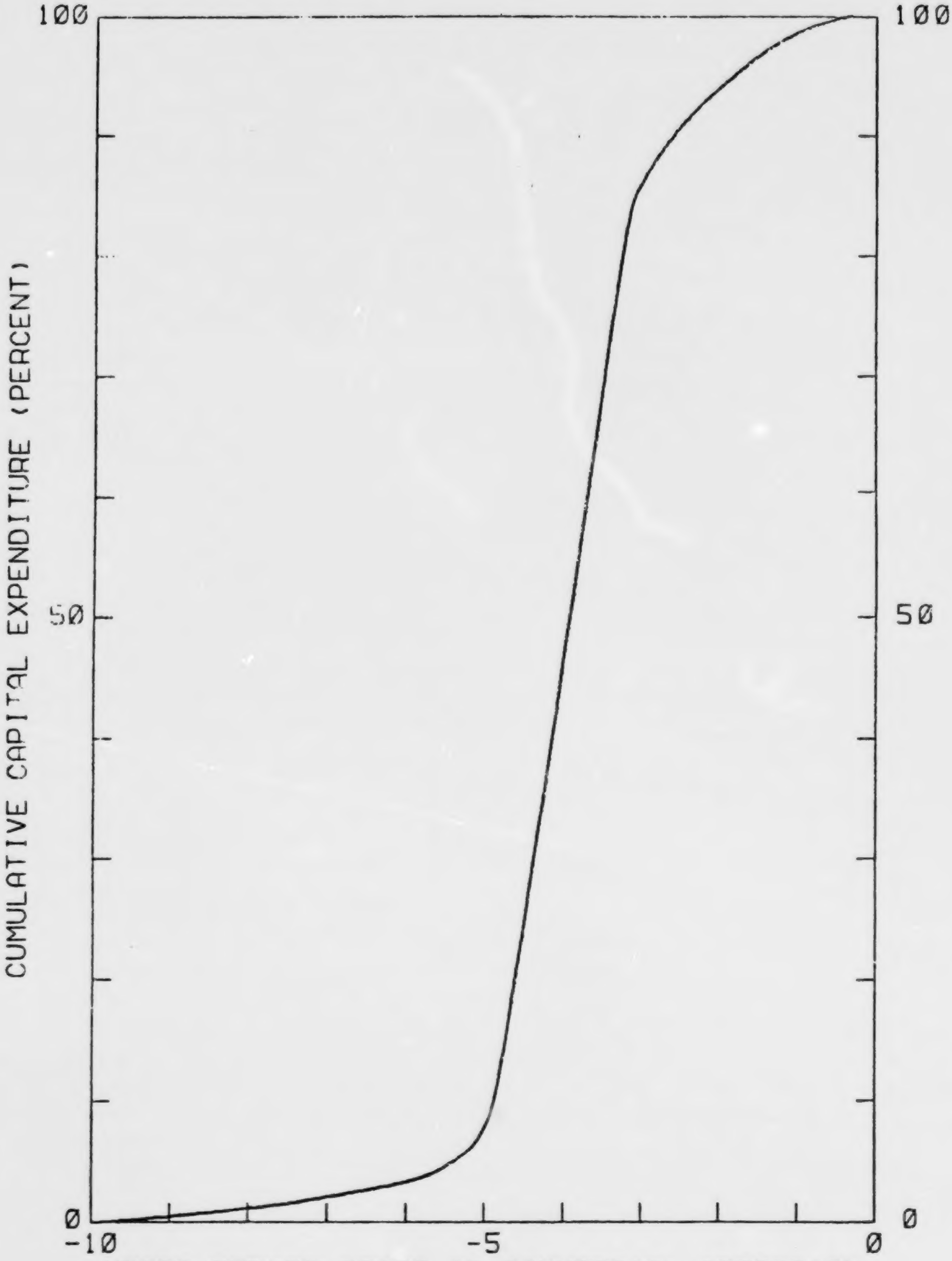

FIGURE 5: TYPICAL MEGA PROJECT EXPENDITURE PROFILE

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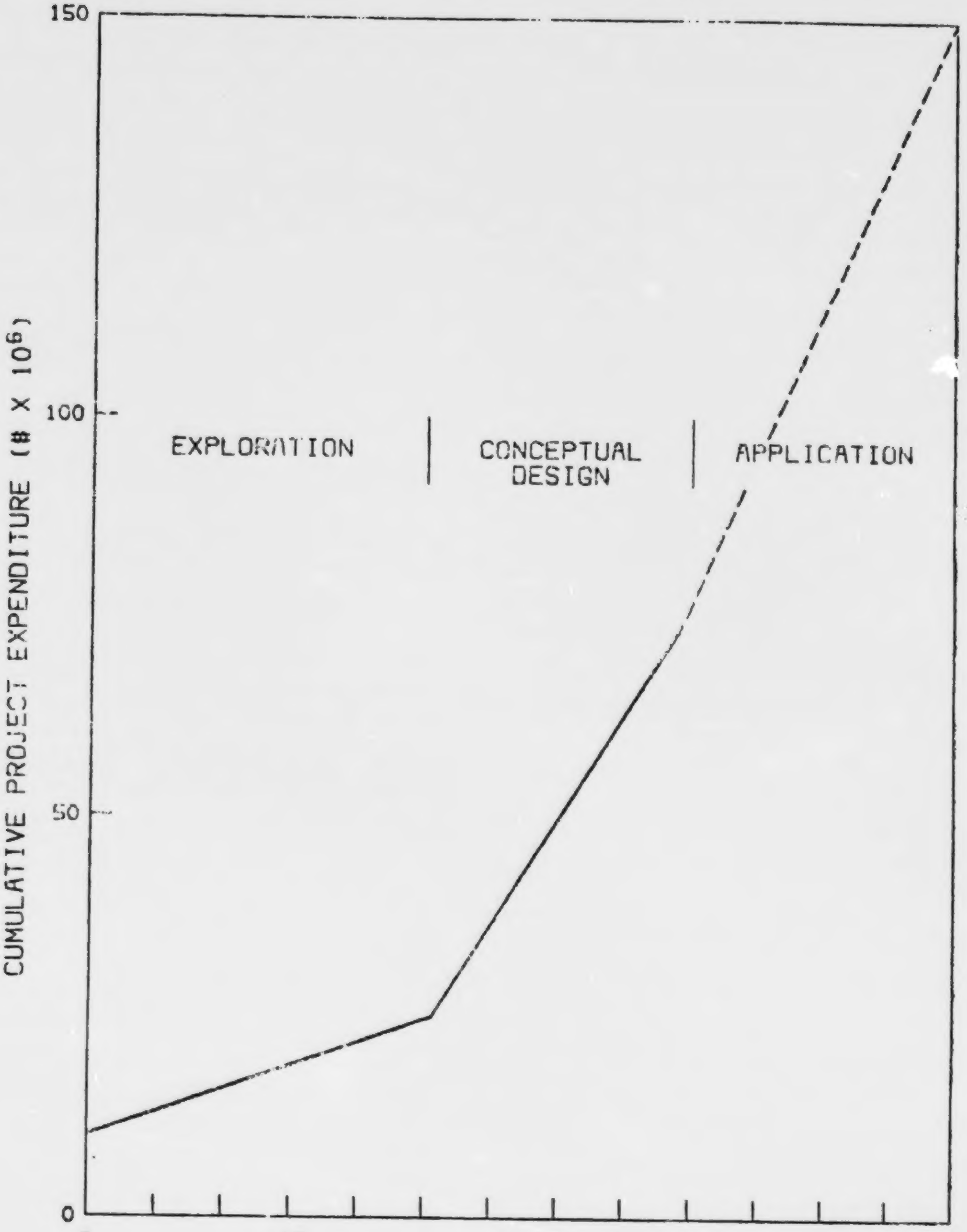

FIGURE 6: TYPICAL MEGA PROJECT EXPENDITURE PROFILE
(EXPANDED SCALE FOR YEARS -18 TO -10)

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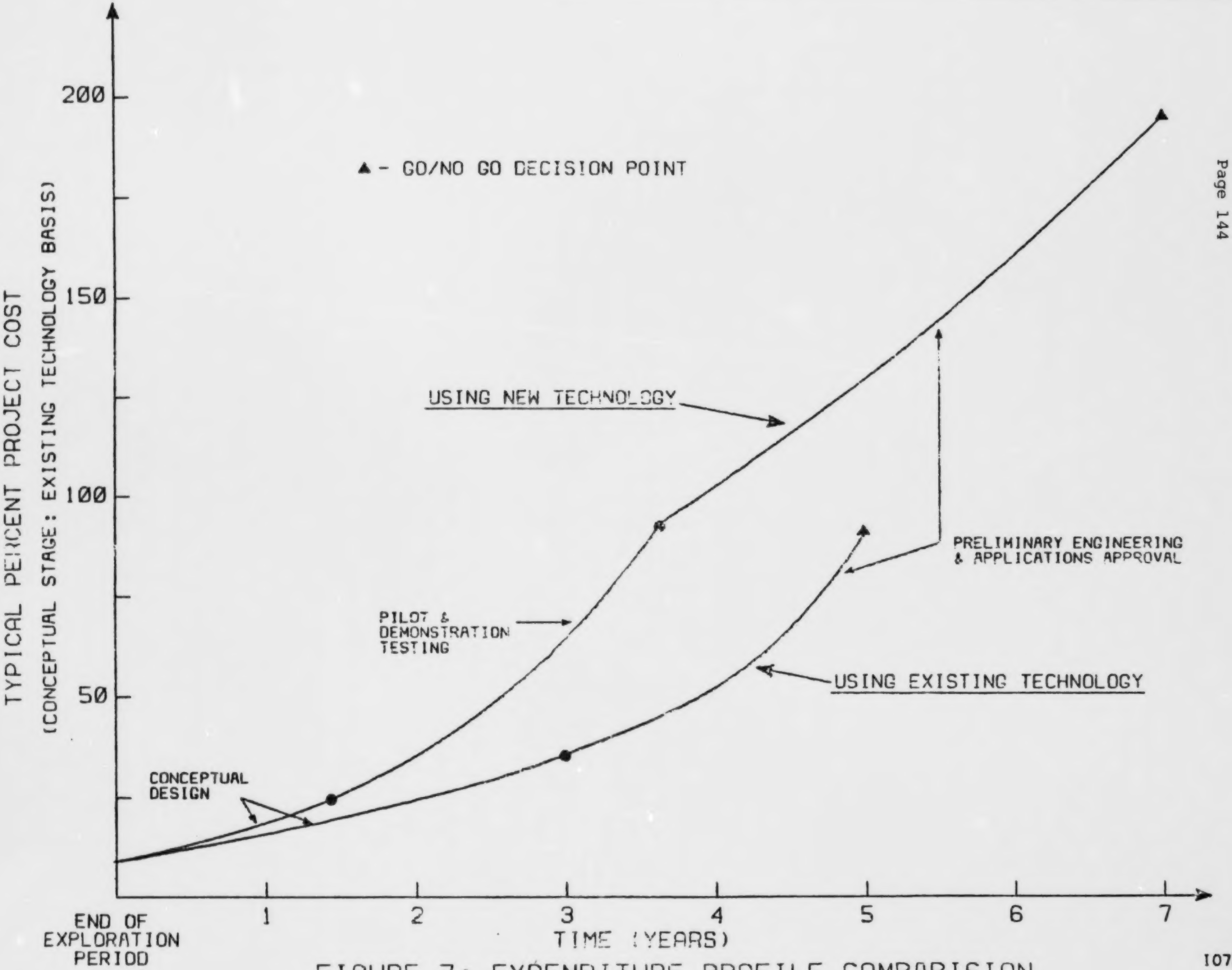

FIGURE 7: EXPENDITURE PROFILE COMPARISION

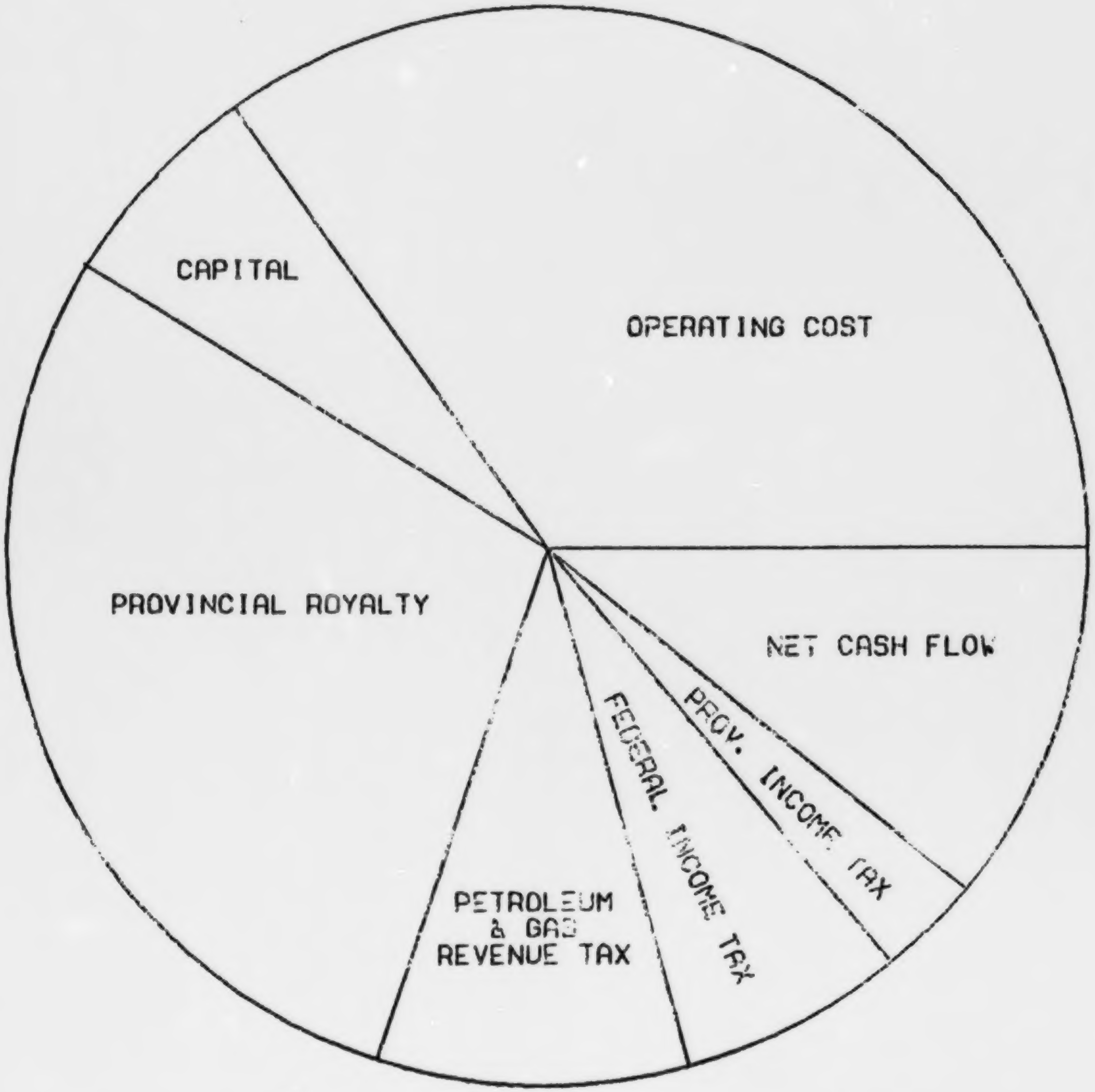

FIG. 8 - LIFE OF PROJECT REVENUE DISTRIBUTION
TYPICAL OIL SANDS MEGA-PROJECT

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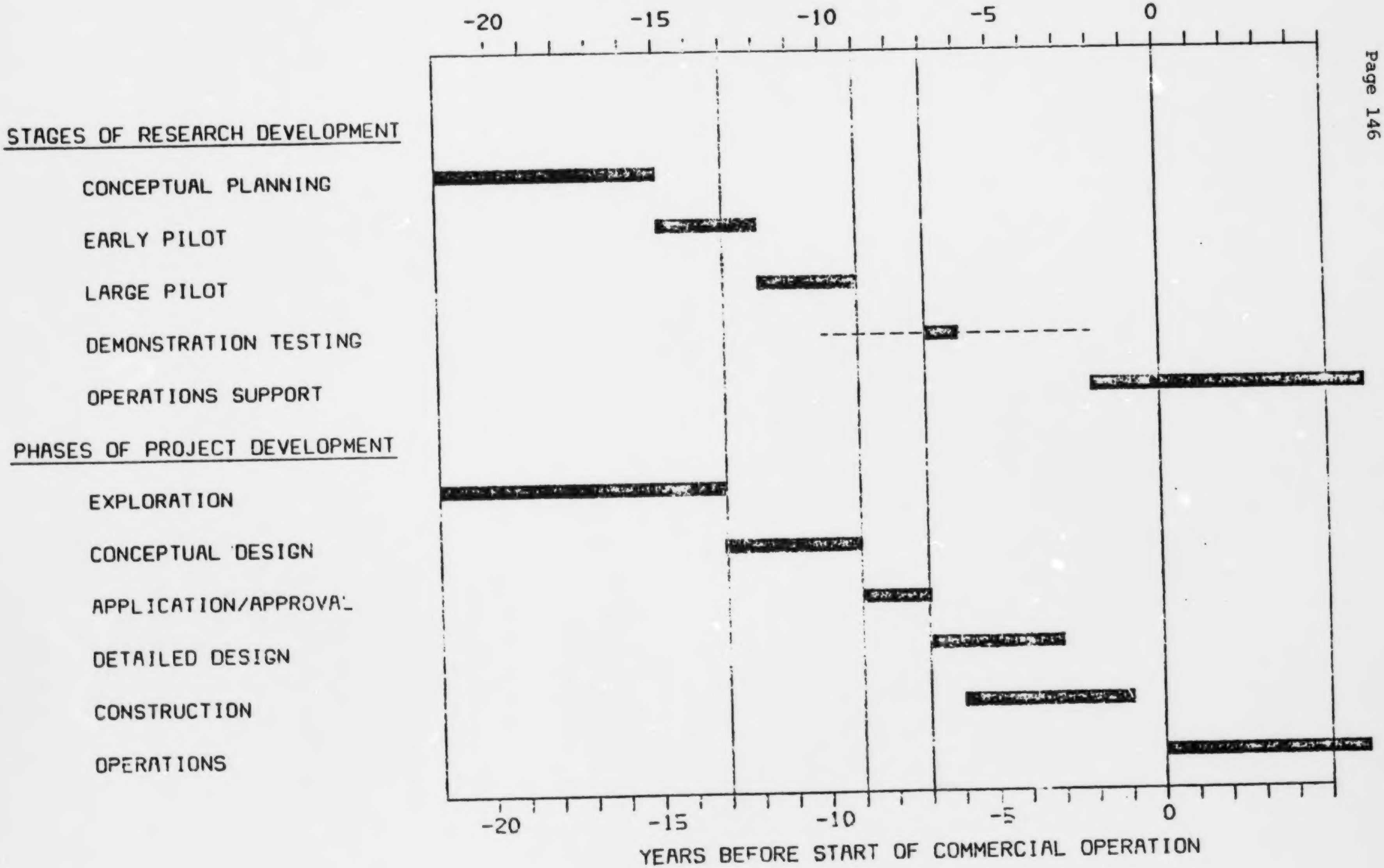

FIGURE 9 STAGES OF RESEARCH DEVELOPMENT VS TIME

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The Concept Development Team reconvened on Monday, October 25, 1982, at 9:00 A.M. Absent were Messrs. Gerry Lewis-Steer and Dave Rose.

Wirth welcomed the team back and advised that the following developments had occurred since the meetings of the group were adjourned on October 15th:

- Merv Leitch has advised that the point of contact with the Alberta Government is to Mr. Vern Mollard of the ERCB. Wirth advised that he will be contacting Mollard in the near future.
- On Saturday, October 23rd, Mike Mears, Sid Jaycock, and Art Wirth met with J. Chretien and his Executive Assistant, E. Goldenberg. At that meeting they apprised Mr. Chretien of the purpose of the Study, the approach being taken, the role and makeup of the Concept Development Team, the kinds of alternates that will probably be identified, and some of the views of the Owner/Potential Owner Companies, etc. Mr. Chretien displayed much interest and asked that we have further dialogue with Mr. Goldenberg. Mr. Goldenberg functions more as a policy advisor to Mr. Chretien than as a more usual Executive Assistant.

Wirth also advised that the Minutes of the Meetings of the Concept Development Team were nearly complete and the work on Task 2 was proceeding.

Meeting times and dates for meetings this week were discussed. It was agreed that meetings would take place Monday through to and including Thursday.

The previous sessions had progressed deliberations to the point where "Musts" and "Wants" had been developed. We are ready to identify Optimal Mineable Tarsands Development Schemes. Morris McClement handed out the following listing of "Wants":

RANK	WANTS	WEIGHT
1	Financial Performance	10
2	Minimum Technical Risk	8
3	Minimum Financial Exposure	9
4	Maximum Operability	8
5	Maximum Expandability	4
6	Maximum Resource Utilization	4
7	Minimum Environmental Impact	4
8	Minimum Administration	4
9	Minimum Adverse Socio-Economic Impacts	2
10	Maximum Canadian Benefits	2

The list was discussed. Ratushny questioned the meaning and intent of "Minimum Administration". It was decided to have this read "Minimum Administrative Complexity". Items 2 and 3 are to be reversed in order. Hyndman noted that the first four items were Economic or Economic-related and carried a total weight of "35". He wondered if this was high. His views were not supported by the group.

It was decided to structure three sub-groups for the purpose of developing alternate schemes and establishing how the options could best be portrayed in Matrix form. The following sub-groups were established.

Group #1 would concentrate on Mining and Extraction, but would not limit themselves only to Mining and Extraction.

Group #2 would concentrate on Upgrading and Utilities, but again would not limit their thinking only to Upgrading and Utilities.

Group #3 would concentrate on Remote Upgrading, Options that involved moving a lower quality material to existing refineries, etc. Again, without being limited to the above.

Group #1	Group #2	Group #3
Morris McClement (leader)	Jim Guthrie (leader)	Tom McCann (leader)
Jim Abbott	Andy Blair	Fred Callaway
Dave Devenny	Doug Kim	Ken Clarke
John Porteous	Gerry Lewis-Steer	John Filby
Fred Ratushny	Bob Wrubleski	Paul White
Dave Rose		

Before breaking up into the three groups, Morris McClement advised that Techman had done further work by way of characterizing the geology basis for considering mining options. He handed out a write-up,with attachments, entitled "Alternate Tarsands Development Generalized Strategraphic Columns". That material is attached hereto. It was proposed that the two stratigraphic columns be used in Stage I as the basis for considering and evaluating alternate mining schemes. It was recognized that the thickness of the bands will not always exist as shown and variances will occur. It was concluded that with appropriate judgements applied, some of which were developed during the ensuing discussion, the proposed columns could be used as the basis for evaluating alternate schemes in Stage I.

The three sub-groups then convened to commence developing alternate schemes as hereto described.

Job No.: 500-30
Date: Oct. 21/82
By: V.S. Pobran

ALTERNATE TARSANDS DEVELOPMENT
GENERALIZED STRATIGRAPHIC COLUMNS

INTRODUCTION

In order to provide a basis for concept development team discussions, two generalized stratigraphic columns have been compiled. These columns are intended to represent two different sets of tarsand ore and waste characteristics which could be encountered in tarsand mining in the Athabasca area north of Fort McMurray, Alberta. Orebody geology has been illustrated by a one-dimensional representation of strata. At this stage of investigation, the exact location of orebodies is not important since any evaluation will be undertaken on a non-site specific basis (at this time). For each of the columns, it has been assumed that sufficient in-place bitumen reserves (at least one billion barrels) exist in the north-south and east-west directions to support a tarsand mining and extraction facility for at least 30 years at a rate of approximately 100,000 BPCD. It has been further assumed that plant feed grade tarsand could be recovered by surface mining methods under present-day economics and existing technology.

DATA REPRESENTATION

In general, the two columns represent the nature of occurrence of the following materials:

1. Holocene Materials
    - muskeg
    - organic soils
2. Pleistocene Materials
    - aeolian dune sands
    - glaciolacustrine clays and silts
    - glaciofluvial sands and gravels
    - glacial tills

3. McMurray Formation

- sheet sands, with alternating ore and waste layers
- thick, well-saturated tarsand which forms the economic zones
- indurated siltstones in the upper 15 meters
- lean tarsand or barren clays described as top, centre or bottom reject
- basal clay and basal sand
- carbonaceous clay and coal
- water sand (containing high pressure, saline water)

4. Waterways Formation

- limestone basement rock

For the purposes of this study, tarsand orebody data has been represented by geologic ages and formations, average stratigraphic thicknesses, layer nomenclature, general comments and some engineering properties. A variety of mining methods and concepts are applicable to these geological scenarios, however, the mining thickness and depth parameters may be summarized as follows:

Parameters	Column No. 4	Column No. 5
Average Overburden Thickness (m)	3	13
Average Mineable Tarsand Thickness (m)	38	53.5
Average Centre Reject Thickness (m)	20	43.5
Average Mining Depth (m)	61	110
Average Waste/Ore Ratio (BCM/BCM)	0.61	1.06

DISCUSSION

The main characterizing features of each column are discussed as follows:

COLUMN NO. 4

- No muskeg - most of the tarsand orebodies in the Athabasca area are covered by muskeg. In this example however, the glacial materials are shown at the surface, and this would be associated with a light tree cover.

- Sheet sand zone - for this case, the upper part of the McMurray Formation is comprised of a series of alternating bands of ore grade tarsand and waste. The recovery of these thin tarsand layers would virtually eliminate large scale equipment (such as bucketwheels and draglines) and would favor small, highly mobile and selective types of excavation equipment. There is sufficient color contrast between the layers to allow for selective mining.

- Basal sand zone - this is a competent material which would provide good trafficability conditions for mobile equipment operated on the floor of the pit. The basal sand and an underlying watersand are known to contain high pressure, saline water. The aquifers would have to be depressurized prior to mining.

COLUMN NO. 5

- Sheet sand zone - a similar occurrence to that described for Column No. 4.

- Indurated siltstone lenses - these hard lenses are usually found in the upper 15 metres of the McMurray Formation and would pose a difficult problem for bucketwheel mining. The usual remedy is blasting in advance of mining.

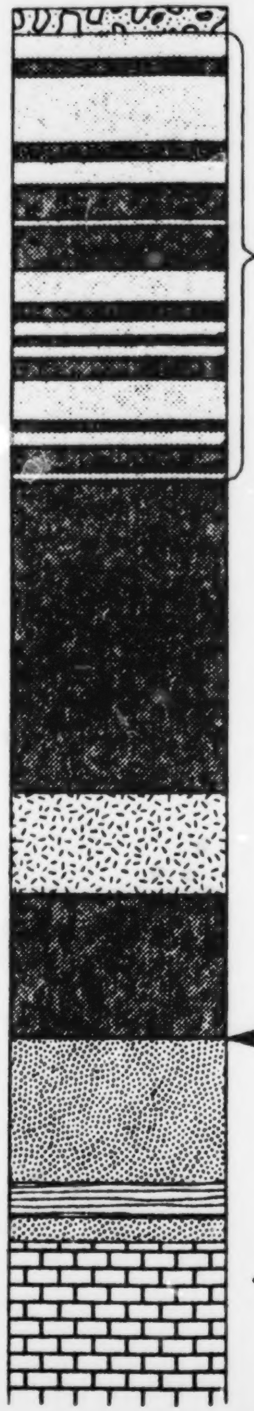
- Basal clay zone and associated watersands - these basal clays would create trafficability and bearing capacity problems for rubber tire and crawler-mounted mining equipment operated on the floor of the pit. The watersands (containing saline water) would have to be depressurized well in advance of mining.

COLUMN NO. 5 (CONT'D)

- Deep payzone - in this example, a thick, fairly well saturated payzone is found under a massive cover of basal clay, carbonaceous clay, coal and watersand. For a mine plan, efforts would be made to maximize the tarsand resource, however, mining economics would govern the recovery of this deep payzone.

ALTERNATE TARSANDS DEVELOPMENT
GENERALIZED STRATIGRAPHIC COLUMN No.4
FIGURE 4.4

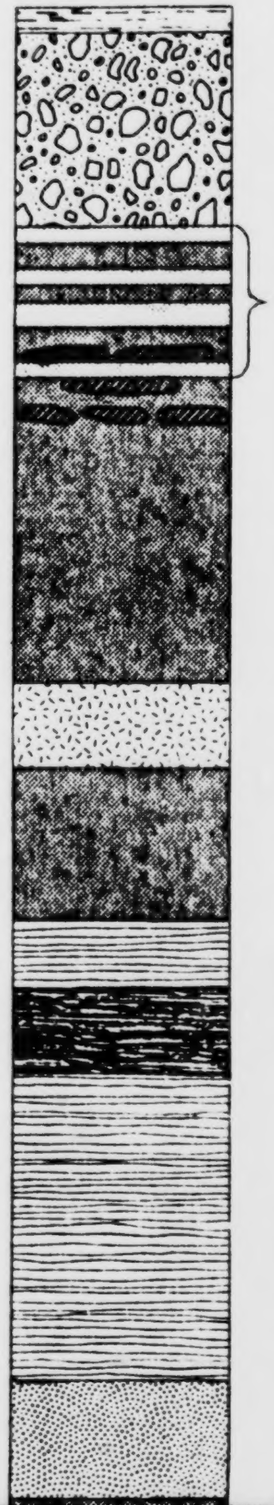
SCALE 1 : 400



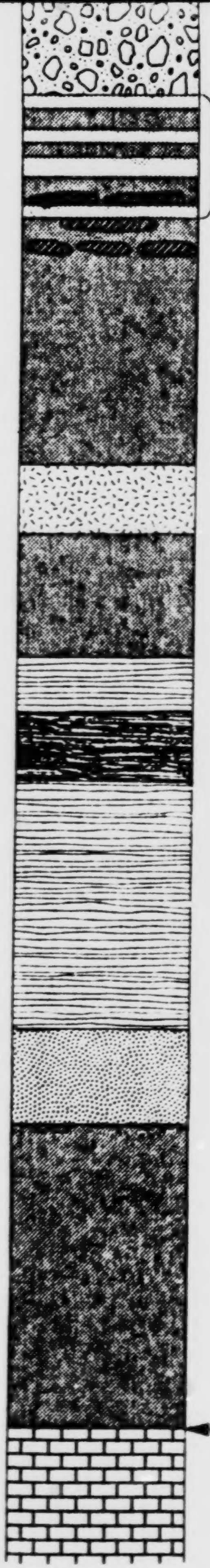
AGE	GEOLOGIC FORMATION	AVERAGE STRATIGRAPHIC THICKNESS (metres)	LAYER DESCRIPTION	GENERAL COMMENTS
QUATERNARY	HOLOCENE and PLEISTOCENE	1.5	OVERBURDEN	This overburden layer is comprised of glacial materials such as glaciolacustrine clays and silts, glaciofluvial sands and gravels, and glacial till. Parts of the associated orebody may also be covered by muskeg, but this is not shown in this example. The groundwater aquifer is found at the base of this layer and is a potential source of granular materials such as clean sands and gravels.
CRETACEOUS	McMURRAY FORMATION	26.5	SHEET SAND ZONE	Alternating layers of ore grade tarsand and waste. The ore grade bands are composed of rich, well saturated tarsand with bitumen contents ranging between 12 and 16%. The waste bands are lean, uneconomic tarsand with grades less than 3%. Bitumen impregnation is controlled by porosity and there is sufficient colour contrast between layers to allow for selective mining.
		18.5	UPPER PAYZONE	Tarsand with minor clay and silt bands (2 - 5 cm thick). This layer is a rich, well saturated tarsand where the sand grains are uniform and medium size (bitumen content = 12%)
		6	CENTRE REJECT	Thick, massive layer of grey plastic clay where any laminations have been destroyed by churning and reworking. Bitumen impregnation is totally absent from this layer.
		8.5	LOWER PAYZONE	Lower payzone materials are similar to the upper, except that the sand grains are coarser and the bitumen saturation averages 14%.
			MINING LIMIT	
		8.5	BASAL SAND	Clean, coarse grained sand at the base of the economic tarsand zone. This basal sand is known to contain substantial quantities of saline water under high pressure. A depressurization program would have to be undertaken prior to mining.
		2	CLAY	Massive, high swelling, kaolinitic clay.
		1.5	WATER SAND	Watersand similar to basal sand.
DEVONIAN	WATERWAYS FORMATION	73	BASEMENT ROCK	Limestone basement rock which forms a stable foundation for overlying materials

ALTERNATE TARSANDS DEVELOPMENT
GENERALIZED STRATIGRAPHIC COLUMN No.5
FIGURE 4.5

SCALE 1 : 400



AGE	GEOLOGIC FORMATION	AVERAGE STRATIGRAPHIC THICKNESS (metres)	LAYER DESCRIPTION	GENERAL COMMENTS
QUATERNARY	HOLOCENE	1.5	MUSKEG	Most of the surface area is covered by muskeg and organic soils. Muskeg is characterized by high water content and low bearing capacity; requires drainage prior to excavation.
	PLEISTOCENE	11.5	OVERBURDEN	This overburden layer is comprised of glacial materials such as aeolian dune sands, glaciolacustrine clays and silts, glaciofluvial sands and gravels, and glacial till. This layer usually contains a groundwater aquifer and is a potential source of granular materials such as clean sands and gravels.
CRETACEOUS	McMURRAY FORMATION	9	SHEET SAND ZONE	Alternating layers of ore grade tarsand and waste. The ore grade bands are composed of rich, well saturated tarsand with bitumen contents ranging between 12 and 16%. The waste bands are lean, uneconomic tarsand with grades less than 3%. Bitumen impregnation is controlled by porosity and there is sufficient colour contrast between layers to allow for selective mining.
		18	UPPER PAYZONE	This upper payzone is mostly a thick, massive and well-saturated tarsand. This layer is a complex mixture of sands, silts and clays, with bitumen impregnation controlled by porosity. The bitumen impregnation is not homogeneous, but varies in richness from 0 to 18% (average bitumen content = 12%). Tabular lenses of indurated siltstone (up to 0.5 m thick) are found frequently in the top 15 m of the McMurray Formation.
		5	CENTRE REJECT	Thick, massive layer of grey plastic clay where any laminations have been destroyed by churning and reworking. Bitumen impregnation is totally absent in this centre reject band.
		9	MIDDLE PAYZONE	Coarse-grained tarsand, where the sand grains were deposited in a high energy, fluvial environment. Some rounded quartz pebbles are clearly visible and the average bitumen content is about 14%, with a range from 10 to 18%.
		4	BASAL CLAY	This basal clay zone is comprised of a massive, high swelling kaolinitic clay. It would be expected that trafficability on this basal clay would be difficult for rubber-tire or crawler-mounted mobile equipment. There is no sign of bitumen impregnation.
		5	CARBONACEOUS CLAY AND COAL	This is a carbonaceous clay layer, with some accumulations of a low-rank sub-bituminous coal. The coal seams are not thick enough to have any economic significance.
		18	BASAL CLAY	This basal clay is similar to the one above.
		7	WATER SAND	Coarse-grained sand deposit with some uneconomic bitumen impregnation. This watersand is known to contain substantial quantities of saline water under high pressure. An aquifer depressurization program would have to be undertaken prior to mining.



QUATE	PLEISTOCENE	11.5	OVERBURDEN	This overburden layer is comprised of glacial materials such as aeolian dune sands, glacio-lacustrine clays and silts, glaciofluvial sands and gravels, and glacial till. This layer usually contains a groundwater aquifer and is a potential source of granular materials such as clean sands and gravels.
CRETACEOUS	McMURRAY FORMATION	9	SHEET SAND ZONE	Alternating layers of ore grade tarsand and waste The ore grade bands are composed of rich, well saturated tarsand with bitumen contents ranging between 12 and 16%. The waste bands are lean, uneconomic tarsand with grades less than 3% Bitumen impregnation is controlled by porosity and there is sufficient colour contrast between layers to allow for selective mining.
		18	UPPER PAYZONE	This upper payzone is mostly a thick, massive and well-saturated tarsand. This layer is a complex mixture of sands, silts and clays, with bitumen impregnation controlled by porosity. The bitumen impregnation is not homogeneous, but varies in richness from 0 to 18% (average bitumen content = 12%). Tabular lenses of indurated siltstone (up to 0.5 m thick) are found frequently in the top 15 m of the McMurray Formation.
		5	CENTRE REJECT	Thick, massive layer of grey plastic clay where any laminations have been destroyed by churning and reworking. Bitumen impregnation is totally absent in this centre reject band.
		9	MIDDLE PAYZONE	Coarse-grained tarsand, where the sand grains were deposited in a high energy, fluvial environment. Some rounded quartz pebbles are clearly visible and the average bitumen content is about 14%, with a range from 10 to 18%
		4	BASAL CLAY	This basal clay zone is comprised of a massive, high swelling kaolinitic clay. It would be expected that trafficability on this basal clay would be difficult for rubber-tire or crawler-mounted mobile equipment. There is no sign of bitumen impregnation.
		5	CARBONACEOUS CLAY AND COAL	This is a carbonaceous clay layer, with some accumulations of a low-rank sub-bituminous coal. The coal seams are not thick enough to have any economic significance.
		18	BASAL CLAY	This basal clay is similar to the one above
		7	WATER SAND	Coarse-grained sand deposit with some uneconomic bitumen impregnation. This watersand is known to contain substantial quantities of saline water under high pressure. An aquifer depressurization program would have to be undertaken prior to mining
		22	LOWER PAYZONE	This lower payzone is located in sand deposits found primarily in "lows" in the Devonian paleotopography. Geophysical logs indicate the bitumen content to be about 10% and this tarsand is sufficiently thick to be considered as mineable.
DEVONIAN	WATERWAYS FORMATION		BASEMENT ROCK	Limestone basement rock which forms a stable foundation for overlying materials

The entire Concept Development Team reconvened at 9:00 A.M., on Tuesday, October 26, 1982. Joining the group was Erdal Yildirim, of Cities Services. Absent was Gerry Lewis-Steer. Wirth welcomed Erdal to the meeting. Morris McClement introduced and provided background information on each of the Concept Development Team members.

Yesterday, the three sub-groups identified potential alternate schemes taking into account the State of the Art as applicable to various technologies. Wirth suggested that the three groups review and share the results of their deliberations. He further suggested that after this had been done, that we form into two restructured groups and advance our deliberations by developing total combined schemes that take into account options of Mining, Extraction, Transport, Upgrading, Utilities, etc.

McClement in reviewing the work of his group advised that about another half-hour would have enabled them to complete the task. In their deliberations they had addressed things in the following order:

1. Listed the things that had to be considered in the Mining and Extraction areas.

2. Reached conclusions regarding geology and available technologies.

3. Identified Mining and Extraction schemes.

In the Mining area three basic schemes should be considered. Those being:

1. Mobile Equipment
2. Dragline/Bucketwheel Combinations
3. Short Haul Mobile Equipment - Separated Extraction

They further felt that cases sized at about 30,000, 50,000, and 100,000 BPCD of bitumen production should be examined. Generally speaking, it was reasoned Dragline/Bucketwheel Combinations would likely emerge as being most economical at operations above approximately 65,000 BPCD and Mobile Equipment Configurations more economically applicable in smaller scale operations.

In the Extraction area the group felt that for projects being undertaken in the near future, the Clarke Hot Water Process, or some derivative thereof, would have to be selected.

The rationale used by the McClement group and the judgements they applied were discussed at some length.

Jim Guthrie, in presenting the results of the deliberations of his group, requested questions and discussions be withheld until his presentation had been completed. The material he presented follows on Pages 157 - 162 inclusive. Jim advised that the group had established for themselves and used the terms of reference shown on Page 162.

During the ensuing discussion, it was proposed by Al Hyndman that the Gulf Solvent Process be considered.

Morris McClement handed out copies of an article that had appeared in the October 18th edition of Business Week, entitled "U.S. tar sands may soon be blooming". A copy is attached hereto.

U. S. tar sands may soon be blooming

Five new plants are now being planned. A potential yield of 35 billion bbl.

Eighteen months after the deaths of two giant tar sands projects shook the Canadian economy, and just as falling oil prices have prompted investors to flee from shale and other synthetic fuel ventures, development of tar sands in the U. S. is attracting unusually widespread interest. As many as five tar sands plants, smaller and less costly than the two now operating in Canada, could be under construction by next year. And with the potential to recover an estimated 35 billion bbl. of oil at stake, "we think we've found a sleeper," says Leonard C. Axelrod, the U. S. Synthetic Fuels Corp.'s vice-president for technology and engineering.

U. S. tar sands deposits will never rival those of Canada, which has an estimated 1 trillion bbl. of tarry bitumen trapped under the soil of Alberta, nor the more than 900 billion bbl. of shale oil in Colorado and Utah. But because oil can be extracted from tar sands deposits in California, Utah, Texas, and Kentucky by conventional mining and oil-upgrading technology, synfuel experts contend that tar sands are better able than other synfuels to yield oil at prices close to those for ordinary crudes.

Great expectations. "Tar sands [development] might not be as feasible as it was two years ago, but it is still profitable. We certainly think so," says William H. Hudson, chairman and chief executive of Dallas-based GNC Energy Corp. GNC sold 75% of its 1,100-acre tar sands holdings in Sunnyside, Utah, in mid-September to Standard Oil Co. of California. With $50 million in Socal equity, the two companies are building a 2,500 bbl.-a-day pilot plant that they plan to expand to a $1 billion, 40,000 bbl.-a-day production effort by 1987. At that time, says Hudson, the $36-a-bbl. crude the plant will produce will be sold to Socal's 45,000 bbl.-per-day Salt Lake City refinery.

The GNC-Socal effort will use conventional strip-mining methods to gain access to source material, rock containing 8% bitumen and 92% silica. Using technology developed by GNC, the Sunnyside project will mix ore and cold water to form a slurry. It then will use diesel fuel to float bitumen out of the tar sands and dissolve it, yielding material with a 30% bitumen content. The extracted bitumen will be shipped to a nearby coking unit, where it will be turned into high-quality synthetic crude. "It is the equivalent of picking up asphalt off the road and putting it back in the barrel," says Hudson.

Canadian tar sands production is centered at two projects in northern Alberta, the 58,000 bbl.-a-day Suncor plant, built by the Sun Co. subsidiary in 1967 for $250 million, and the 80,000 bbl.-a-day Syncrude Ltd. project, built in 1978 for $2.3 billion by a consortium led by Exxon Corp. Until recently, extracting oil from tar sands created environmental problems that ruled out operations in the U. S. The processes in use at Suncor and Syncrude, in which bitumen-laden soil is washed in hot water to free the oil, creates large pools of highly contaminated clay and silt, says John S. Rendall, a plant manager for several Canadian pilot projects in the late 1970s. "You could get away with that kind of thing in Canada, where there is vast wilderness," he says, "but the U. S. government wouldn't allow that here."

Gwendolyn Stewart

Vice-President Axelrod says that Synfuels Corp. thinks "we've found a sleeper."

Rendall is president and director of Solv-Ex Corp., an Albuquerque company that plans to build a $24 million unit on an 800-acre site in Santa Rosa (N. M.) containing 19.3 million bbl. of potential reserves. Rendall claims that his process minimizes waste problems by using solvents in concert with hot water. He adds that the Sol-Ex process can boost yields from U. S. tar sands deposits, which usually contain half as much bitumen as those in Canada. The 4,000 bbl.-a-day project he plans to build, using equity of $3.6 million raised in a public stock offering in 1981, will convert the heavier, high-sulfur oil into a "sweet" crude that Rendall claims he can sell at a highly competitive $25 per bbl.

Government backing. Rendall claims that strip mining represents nearly three-quarters of the costs of his project. He adds that uncertainty over the eventual success of his venture—and of the others being contemplated—makes federal assistance necessary before major commercial production of tar sands properties can begin. Solv-Ex and the Sunnyside project are among five tar sands projects in a group of 11 proposals that Synfuels Corp. is considering under a $14 billion solicitation earlier this year. By early 1983, at least one of the five is likely to be given federal backing, probably through price supports or loan guarantees, according to industry experts.

Synfuels' Axelrod will not reveal which venture has the inside track. But he believes that projects using conventional technology "make them the ideal kind of investment for this corporation—one that has the opportunity to produce fuel quickly." Most tar sands operations can be built within a year, says Axelrod, because they involve little heavy process equipment. But industry experts worry that the trail of problems at the Canadian projects, which have included failure of equipment in Alberta's subzero weather, may dissuade private investors.

Still, La Jolla (Calif.)-based Enpex Corp., headed by former Office of Management & Budget energy officials Richard H. Hertzberg and Joseph P. Kearney, has been guaranteed $50 million in equity from limited partners—including Superior Oil Co. and Getty Oil Co.—to create Texas Tar Sands Ltd. The partnership already has spent $13 million and is seeking federal price supports to build a plant that will produce 3,000 to 5,000 bbl. a day using Conoco Inc. technology at the San Miguel field in southern Texas. The process, which recovers oil through the injection of steam directly into formations, would produce oil at an estimated $45 a bbl. and is said by its backers to be more efficient than are other techniques for recovering oil from tar sands.

Industry rumors, meanwhile, say that Mobil Corp., which undertook extensive testing of its own tar sands process in the early 1960s, or Standard Oil Co. (Ohio), which has significant tar sands reserves in Texas, may soon announce ventures as well. None is likely to be the size of the 140,000 bbl.-a-day tar sands projects scrapped in Canada—the $10 billion Cold Lake venture or the $11 billion Alsands project. But, says Solv-Ex's Rendall, "the U. S. projects are at least moving ahead." ■

Synfuels: Down but not out

A lingering world oil glut, falling energy prices, and the uncertainty of using untried technology in building multibillion-dollar plants have aborted synthetic fuel ventures and dashed the dreams of those who hoped synfuels would become a quick fix for U. S. dependence on imported oil. But the industry is far from dead. Armed with various forms of federal support, several synfuel projects that use coal or shale are steadily moving toward completion.

Union Oil Co. of California, with a price guarantee issued by the Reagan Administration in 1981, is halfway through construction in Garfield County, Colo., of the nation's first commercial shale oil plant. The Parachute Creek plant will produce 10,000 bbl. per day of diesel and jet fuel from the shale and is expected to cost about $600 million by the time it is completed in mid-1983. The Defense Dept. has agreed to buy the plant's entire output at an initial price of $42.50 per bbl., and Union wants to expand Parachute Creek's capacity to 90,000 bbl. per day by 1994.

In Beulah, N. D., meanwhile, construction of the $2 billion Great Plains coal gasification project, the most expensive U. S. commercial synfuel project, is about 25% complete. The plant, which will use 4.7 million tons of lignite annually and will produce 125 million cu. ft. of pipeline-quality gas daily, is sponsored by a five-company consortium that put up $561 million in equity and received a $2.02 billion federal loan guarantee in 1981. Sponsors say the plant will be producing gas in late 1984.

Consortium. And in Daggett, Calif., construction is 10% complete on a $300 million project that will produce electricity by converting coal to gas that will fuel a combined-cycle turbine. The 90 Mw project is sponsored by a consortium that includes Texaco, General Electric, Southern California Edison, and a group of Japanese companies. Southern California Edison, which will operate the unit, is seeking federal price guarantees.

Several other projects, including a $70 million plant in Kingsport, Tenn., that will convert coal into gas to be used as a chemical feedstock, are also under way. Tennessee Eastman Co., an Eastman Kodak Co. subsidiary, began the plant in 1980 with internal funds and expects to complete it by late 1983.

Exxon Corp.'s decision last May to

CONVERSION PROCESSES

	State of Art
Delayed Coking	P
Fluid Coking	P
Flexicoking	D+
H-Oil/L-C Fining	D+
Canmet	D-
Visbreaking	D
Hydrovisbreaking	D-
HDS/Delayed Coking	D+
HDS/Fluid Coking	D+
Veba	D-
U O P Aurabon	D-
Eureka	D
Dynacracking	N
HDM/H-Conversion	D-
Deasphalting	D+
Visbreaking/Deasphalting	D
Direct Coking - Lurgi	D-
- Taciuk	D-
Sand Removal - Lurgi	S

P - Proven

D - Developing

N - No Go

D+ - Commercially Demonstrated

D- - Pilot Scale or Bench

S - Further Study

SINGLE TRAIN
NOMINAL CAPACITY MB/CD PLANT PRODUCT

SIZING PROCESS

	MINIMUM	MAXIMUM	POSSIBLE MODULE SIZE
Delayed Coking (P)	10	65-75	20
Fluid Coking (P)	10	65	20
Flexicoking (D+)	10	65	20
H-Oil/L-C Fining (D+)	10	45	20
Visbreaking (D)	10	65-75	20
HDS/Delayed Coking (D+)	10	45	20
HDS/Fluid Coking (D+)	10	45	20
Eureka (D)	10	65-75	20
Deasphalting (D+)	10	65-75	20
Visbreaking/Deasphalting (D)	10	65-75	20
HDS/Flexicoking (S)	10		
Sand Removal (S)	10		

FACILITIES REQUIRED UPSTREAM & DOWNSTREAM
OF BASIC CONVERSION PROCESS
AS SHOWN ON PAGE

UPSTREAM	DOWNSTREAM
(DRU) VAC. FLASH (VFU)	(GRU, HTU's, AMINE, S. T.G. CLEANUP (?)
(DRU) VFU	(CO BLR, FGD, CRU, HTU's, AMINE, S. T.G. CLEANUP).
(DRU) VFU	DRU, HTU's, AMINE, S, T.G. CLEANUP (?) FLEXI-GAS TRT.
(DRU) VFU	GRU, HTU's, AMINE, S.
(DRU)	
(DRU) VFU	DRU, HTU's AMINE, S. T.G. CLEANUP (?)
(DRU) VFU	CO BLR, FGD (?), DRU, HTU's, AMINE, S, T.G. CLEANUP
(DRU) VFU	GRU, HTU's, AMINE, S. T.G. CLEANUP (?)
(DRU) (VFU)	HYDROCRACKER, GRU, AMINE, S, T.G. CLEANUP
(DRU)	- - - - - - -"- - - - - - -

H_2 GENERATION AND FUEL CONSIDERATIONS FOR BASIC CONVERSION PROCESSES AS SHOWN ON PAGE

H_2 GENERATION	FUELS
N.G. Reform Coke Pox $(+O_2)$	Purch. N.G. Coke Pox Coke (+FGD or FBC) Ref. Gas Stockpile Coke
N.G. Reform. Coke Pox $(+O_2)$	---------"----------
N.G. Reform. Ref. Gas Reform.	Purge Coke (?), Purch. N.G. (?) Ref. Gas, Stockpile Purge Coke Lo BTU Gas
N.G. Reform. Resid. Pox $(+O_2)$ Ref. Gas Reform	Purch. N.G. (?) Resid. Pox Ref. Gas. Resid. + FGD or FBC (?)
N.G. Reform. Coke Pox $(+O_2)$	Purch. N.G. Sell Coke (?) Coke (+FGDOR FBC) Coke Pox Ref. Gas
N.G. Reform. Coke Pox $(+O_2)$	--------"--------
N.G. Reform. Resid. Pox $(+O_2)$	Purch. N.G. Ref. Gas Resid. Pox Resid. + FGD or FBC (?) Resid. Pox
N.G. Reform. Ref. Gas Reform. Asphalt Pox $(+O_2)$	Purch. N.B. (?). Ref. Gas Asphalt Pox Asphalt + FGD or FBC (?)
--------"--------	--------"--------

FUEL & UTILITY OPTIONS

Excess Fuel Options	Utility Options
Coke Ref. Gas	Export Power Stockpile Coke Sell Fuel
Coke Ref. Gas	------"------
Purge Coke Lo BTY Gas Ref. Gas	------"------
Hi Conv. - Nil	
Low Conv. - Resid.	Sell Resid. or Blend. Sell Lo into Syncrude (?). Export Power BTU Gas
In Balance (?)	
In Balance (?)	
Pitch	Sell Pitch, Lo BTU Gas; Export Power
Asphalt	Sell Asphalt, Lo BTU Gas; Export Power
In Balance (?)	

UPGRADERS/UTILITIES

TERMS OF REFERENCE

1) Develop technically feasible schemes for stand-alone upgraders.

2) Identify and prioritize technologies.

3) Schemes suitable for short term project initiation.

4) Identify primary upgrading schemes, then derived related upstream and downstream processes.

5) All schemes make refinery quality synthetic crude.

6) Identify range of plant sizes.

7) Identify fuel balancing options.

FURTHER WORK

- Partial Upgrading Schemes.
- Integrated Schemes with M & E.
- Utilities for all schemes.

Tom McCann presented the results of his group's deliberations. The flip chart material he spoke to follows as Pages 165 to 170 inclusive.

During the discussion that followed Tom's presentation Erdal questioned whether options should be identified and developed that took into account the severity of winter climatic conditions and considered factors such as enclosing more of the facilities, shutting down the operation for maintenance and turnaround during the winter months, etc. The group concluded that this type of detail could not really be taken into account in the Stage I part of the study. It was, however, agreed that in selecting processes and hardware the ability of the facility and hardware to operate and function in these climatic conditions should be taken into account.

Before breaking into two groups, the Concept Development Team developed a set of ground rules to use in their deliberations as they relate to the identification of alternates. The ground rules developed were:

ALTERNATE GROUPINGS

Fully integrated in field
Bitumen production only. New Upgrader at Edmonton
Bitumen production only. Piggyback at Syncrude/Suncor
Bitumen production only. Piggyback at Edmonton Refineries

Miscellaneous:

Retort
Mixed Mine Types (Conventional and Slurry)
Mixed Extraction Types
Field Energy Options
Multiple Mine Options
Product Quality

FULLY INTEGRATED

Field - 1 Mine - Conventional — Alts to 1 to 24
- Slurry Transport — S/M/L

Field - 1 Extraction - Conventional
- Solvent
- Retort

Field - 1 Upgrader - H_2 First
C Rem. First

- -

Bitumen Production Only - New Upgrader at Edmonton Alts 25 to 80

Field - 1 Mine - Conventional
- Slurry

Field - 1 Mine	- Conventional - Solvent - Retort	Field Energy Subset Multiple Mines Subset
Edmonton - 1 Upgrader	- H_2 First - C Rem. First	

Note: S/M - Get Diluent from S/S
L - Use Visbreaker or equal or Diluent Pipeline

* * *

Bitumen Production Only Piggyback on S/S

Field - 1 Mine	- Conventional - Slurry	Alts 49 - 60
Field - 1 Extraction	- Conventional - Solvent - Retort	S/M/L Subset on Field Energy
S/S - 1 Upgrader	- H_2 Add - MT (only for Retort)	Subset on Mines

* * *

Bitumen Production only Piggyback on Edmonton's Refineries		Alts 61 to 69
Field - 1 Mine	- Conventional - Slurry	S/M/L Subset on Field
Field - 1 Extraction	- Conventional - Solvent - Retort	Energy
Edmonton Refineries - 1 Upgrader	- Specific (H_2+)	Subset on Mines

S/M - Diluent from S/S
L - Visbreak or Dilute return Pipeline

* * *

Retorting	Alts 69 - 75
1 - Mine	S/M
1 - Extraction	
1 - Upgrader - H_2 Add - S/S - Field - Edmonton Refineries	

- -

Slurry Oil Sand	Alts 76 to 78
Conventional Oil Sand Transport	
X Mines	S/M/L
1 Extraction - Conventional	Subset or Field Energy

- -

Alt. Prod. Quality

MINES	- Conventional	S		
	- Conventional	M		
	- Slurry	S		
	- Slurry	M		
	- Slurry	L		
EXTRACTION	- Conventional	S		
	- Conventional	M		
	- Conventional	L		
	- Solvent	S		
	- Solvent	M		
	- Solvent	L		
	- Retort	S		
	- Retort	M		
UPGRADER	- S/S H_2t	S		
		M		
		L		
	- S/S HT	S	(for retort)	TRANSPORT
		M	(for retort)	
UTILITIES	- New H+	S		
		M		
		L		
	- New C	S		
		M		
		L		
	- Edm. H+	S		
		M		
		L		
	- Field VB	L		

SUBSET

Field Fuel Options | **50# Steam**

Pipelines
- Natural Gas

Truck
- Conventional
  Coke
  Pitch

Fluid Bed - Limestone
Mine) Sludge
) to
FGD -) Mine

Truck
- Liquid
  Hvy. FV

Pipelines - - - - - - - - - - - - - - - - - - Gasification
Low Bitumen
(on site)
Med. BTU Gas
H_2 (at Upgrader)
Air Sep.
needed
(likely central)

Truck
- HT'd Coke (los)
  HT'd Pitch (los)

Electrical

- Import
- On Site Generation - in a steam

Oversights/Neglects

1. Only Canadian Product Markets

2. Neglected Byproducts

   i.e., No impact on system selection

3. Left Mining, Extraction and Upgrading optimizing and breakthrough identification to other groups.

Non-physical Constraints Identified

1. Transfer pricing in various schemes.

2. Uniform tax, royalty treatment

1. Identify Alternate Schemes based on different technologies and different sizes using technology that is proven now or will be sufficiently proven a year from now to make it acceptable from a risk standpoint.

2. Secondly, identify technologies that are in the development that potentially are very attractive, but require further development work that can be accelerated to achieve a state of commercial acceptability by the early 1990's. Additionally, identify the driving force or impetus of these technologies and establish what needs to be done to demonstrate commercial applicability.

3. Sizing Cases:

   a) 25,000 BPCD Bitumen Production
   b) 50,000 BPCD Bitumen Production
   c) 100,000 BPCD Bitumen Production
   d) Step-wise approach to (c)

4. Mineable ore depth to 225 feet with schemes to test against other depth ranges.

5. Ore grade 11-1/2% Bitumen - 16%
   (related to minerals)

The following two groups were established:

Group #1	Group #2
Jim Guthrie (leader)	Morris McClement (leader)
Jim Abbott	Fred Callaway
Andy Blair	Ken Clarke
Dave Devenney	John Filby
Al Hyndman	Doug Kim
Gerry Lewis-Steer	Tom McCann
John Porteous	Fred Ratushny
Paul White	Dave Rose
Bob Wrubleski	Erdal Yildirim

It was agreed that the two groups would reconvene into one group at 1:00 P.M. on Wednesday, October 27, 1982.

The two groups then went to work in separate sessions.

The Concept Development Team reconvened at 1:00 P.M. on Wednesday, October 27th. Jim Guthrie and Morris McClement each took about half an hour to review the work done by their respective groups during the past day or so.

Speaking from flip chart material, Jim reviewed the results of his group's activities. Copies of the flip chart material follow and are identified as Pages 173 to 184 inclusive.

Jim Guthrie's group had also commenced work on the task of identifying technology enhancement options. Jim asked John Porteous to review the material shown on Page 181. He pointed out that they wished to do further work on this aspect. Jim felt that we needed to get a fix on the size to use, particularly in the staged or modular cases.

Morris McClement advised that his group had made a listing of additional ground rules, discussed technology considerations and developed most, but not all, of their cases. The additional ground rules appear as Pages 182, 183, 184 . Morris advised that his group needed to finish developing cases and address technology enhancement possibilities.

It was decided to use the 100,000 BPCD of Bitumen Production as the Base Case and assess other options with respect to the Base Case.

Since there was some confusion as to what was meant by a Short Haul Mining Case, Dave Devenny illustrated this on a flip chart. This appears on Page 185 of this report.

It was decided that Thursday would be spent as one group finalizing the Cases to be subsequently evaluated and finalizing the technology enhancement possibilities to be further examined. The two groups then returned to their separate deliberations to complete their tasks.

MINING

NOW CASES

1. (a) Mobile Equipment/Conveying
   (b) BWE/Conveyor
   Dragline (bottom)
   (c) Short Haul - separated extraction

FUTURE

Minimize Materials Handling Cost:

- Excavate/Slurry
- Short Haul Distance (relocatable extraction)
- Dredging (O.B. Only)
- X - Pit Conveying (O.B.)
  - & long boom dragline options

EXTRACTION

NOW CASES

2. (a) State of the Art Hot Water

Conventional Tailings (improved?)

FUTURE

Hot Water Enhancements

- Recovery
- Energy Consumptions
- Sludge Disposal/Elimination

Relocatability

Direct Coke Retort

Solvent (?)

UPGRADING

NOW CASES

3. (a) Delayed Coking
   (b) Fluid Coking
   (c) Flexi Coking
   (d) L.C. Fining/H-Oil (Lo-Conversion)
   (e) Visbreaking (transport to remote Upgrader)

- -

FUTURE

L.C. Fining/H-Oil (Hi-Conversion)

SRB (Gulf)

Canmet

Direct Coking (See Extraction)

UTILITIES

NOW OPTIONS

Fuel Utilization

Steam from - Natural Gas
- Refinery Gas
- Coke (FGD)
- Resid (S?)

H_2 from - Refinery Gas
- Resid
- Natural Gas

Electric Power from - Steam
- Gas Turbine
- Gas Engine
- Diesel
- Tie Line
- Expander Turbine

- -

FUTURE

Fluid Bed Boiler (Near Term)

Nuclear

INTEGRATED PLANT

Mine and Extraction provide Upgrader feed and they are located in the same geographic locations.

S = Staged

CASE		SIZE
I	Mobile Equipment/Conveying	25, 50, 100 S
	State of the Art Hot Water Conventional Tailings (improved?)	
	Delayed Coking	
II	Mobile Equipment/Conveying	100 S
	State of the Art Hot Water	(50 ---> 100)
	Fluid Coking	
III	Mobile Equipment/Conveying	S (50 ---> 100)
	State of the Art Hot Water Conventional Tailings (improved?)	
	Flexi Coking	
IV	Mobile Equipment/Conveying	100
	State of the Art Hot Water Conventional Tailings (improved?)	
	L.C. Fining/H-Oil Lo-Conversion ---> Fluid Coking	
V	BWE/Conveyor Dragline (bottom)	50, 100
	State of the Art Hot Water Conventional Tailings (improved?)	
	Fluid Coking	
VI	Short Haul - separated extraction	S (50 ---> 100)
	State of the Art Hot Water Conventional Tailings (improved?)	
	Fluid Coking	

NON-INTEGRATED PLANT(S) - DEFINITION

NOW

One or more energy systems are not integrated.

PLANT ALTERNATES - GROUND RULES

NOW

1) Close proximity M & E/UG
   i.e., separate energy source (likely steam) at M & E

   a) - M & E to feed central, stand-alone U.G.

   b) - Use Suncor/Syncrude U.G. and facilities

2) U.G. at Edmonton Area

   - Use existing refinery facilities

   - Stand-alone M & E

   - Stand-alone U.G. at end of P/L

   a) Diluent Case

   b) Visbreaker (?) Case at Site

   c) Sulphur Removal at Site

NON-INTEGRATED PLANT

CASE		SIZE
VII	Short Haul - Separated Extraction	25, 100 (U.G.)
	State of the Art Hot Water Conventional Tailings (improved ?)	
	L.C. Fining/H-Oil Lo-Conversion --> Fluid Coking	
	• U.G. in Edmonton	50, 25 (M & E)
	• Transportation - Visbreaking - Diluent	
	• Surplus fuels to be disposed of	
VIII	Short Haul - Separated Extraction	25, 50
	State of the Art Hot Water Conventional Tailings (improved ?)	
	L.C. Fining/H-Oil Lo-Conversion --> Fluid Coking (?)	
	• Min. U.G. at Site	
	• Mods. to Existing Refinery a) in Edmonton b) in Mid-U.S.	

NON-INTEGRATED PLANT

CASE	SIZE
IX Short Haul - Separated Extraction	50, 100
State of the Art Hot Water Conventional Tailings (improved ?)	
L.C. Fining/H-Oil Lo-Conversion	
Mods. to Suncor/Syncrude to optimize throughout	
X Short Haul - Separated Extraction	25, 100 (U.G.)
State of the Art Hot Water Conventional Tailings (improved ?)	
L.C. Fining/H-Oil Lo-Conversion ---> Fluid Coking	
• Central U.G. in Region	25, 50 (M & E)
• Stand-alone M & E	
• Close Proximity	

JUSTIFICATION

ENHANCEMENTS

MINING/EXTRACTION

- Goal in M/E is to minimize materials handling
    - Insitu Mining for intermediate or surface depths

MOBILE SEPARATION PLANTS

- Direct Retort Process - on skids, barge, crawlers, walkers
- Pit Bottom - no trafficability or other level in the mine

- Goal to minimize tailings system impact
    - Improved Hot Water, RTR
    - Direct Retorting

- Goal to increase extraction and upgrading efficiency (recovery energy)

(1) Direct Retort Process
(2) Maximum U.G. Conversion - ex. H-Oil - High Conversion
(3) Extraction Efficiency
    - spherical agglomeration
    - Syncrude 2-Stage
    - RTR
    - Kruyer Process
    - Solvent Processes for satellite use, Dravo, Magma
(4) Utilities Fluidized Bed Combustion
    - use waste products for fuels

CONCLUSIONS

1. Mobile Separation Plants (Extraction)
2. Direct Retorting
3. Max. U/G Conversion
4. Fluidized Bed Combustion in Utilities

UPGRADING

1. Can be physically removed from upstream units. Remove Upgrader (Edmonton?) or added to existing facilities (Syncrude, Suncor Refineries).

2. Only technologically proven primary U/G Processes are:

   - Coking Fluid and Delayed
   - H-Oil/L.C. Fining (60-70% Conv.) (Can be used in combinations - H+ and Coking.)

3. In general, Coking Processes are energy exporters.

4. Coking Processes are low yield, H+ Processes are high yield.

5. High Conversion H addition processes in development are:

   - High Conversion H-Oil/L.C. Fining, Aurobon, Gulf DRB Process, Canmet, Veba, are potential enhancements driven by high yields, low byproduct production.

   - Retorting Processess (Taciuk, Lurgi) are driven by economics, environmental considerations.

6. There is an economic need for processes to use byproduct - pitch, coke, etc. (flexi-coking).

7. De-ashing technology could move flexi coking to proven.

MINING

1. Independent of downstream (equipment selection).
2. For a given geology, selected scheme is a function of size.
3. Hydraulic Mining/Slurry Transport of Tarsands is a potential future enhancement, probably driven by flexibility and economics.
4. Carry two schemes at each size (differentiate between wheels and D/L's at each size).

EXTRACTION

1. Extraction/Froth Treatment Plant should be as close as practical to Mining.
2. Extraction requires low level energy in large, variable quantities.
3. CHW* is the only technologically proven process.
4. Extraction requires water.
5. Potential future enhancements include:
   - Low Temperature Improvement to CHW
   - Froth Treatment Improvements
   - Solvent Recovery
   - Oleophilic Separation
   - Direct Retorting
   - All driven by recovery efficiency, economics, and by environmental considerations.

* Improvements to CHW, in the area of low temperature separation, froth treatment, are likely to be available within the development time-frames of the next plant.

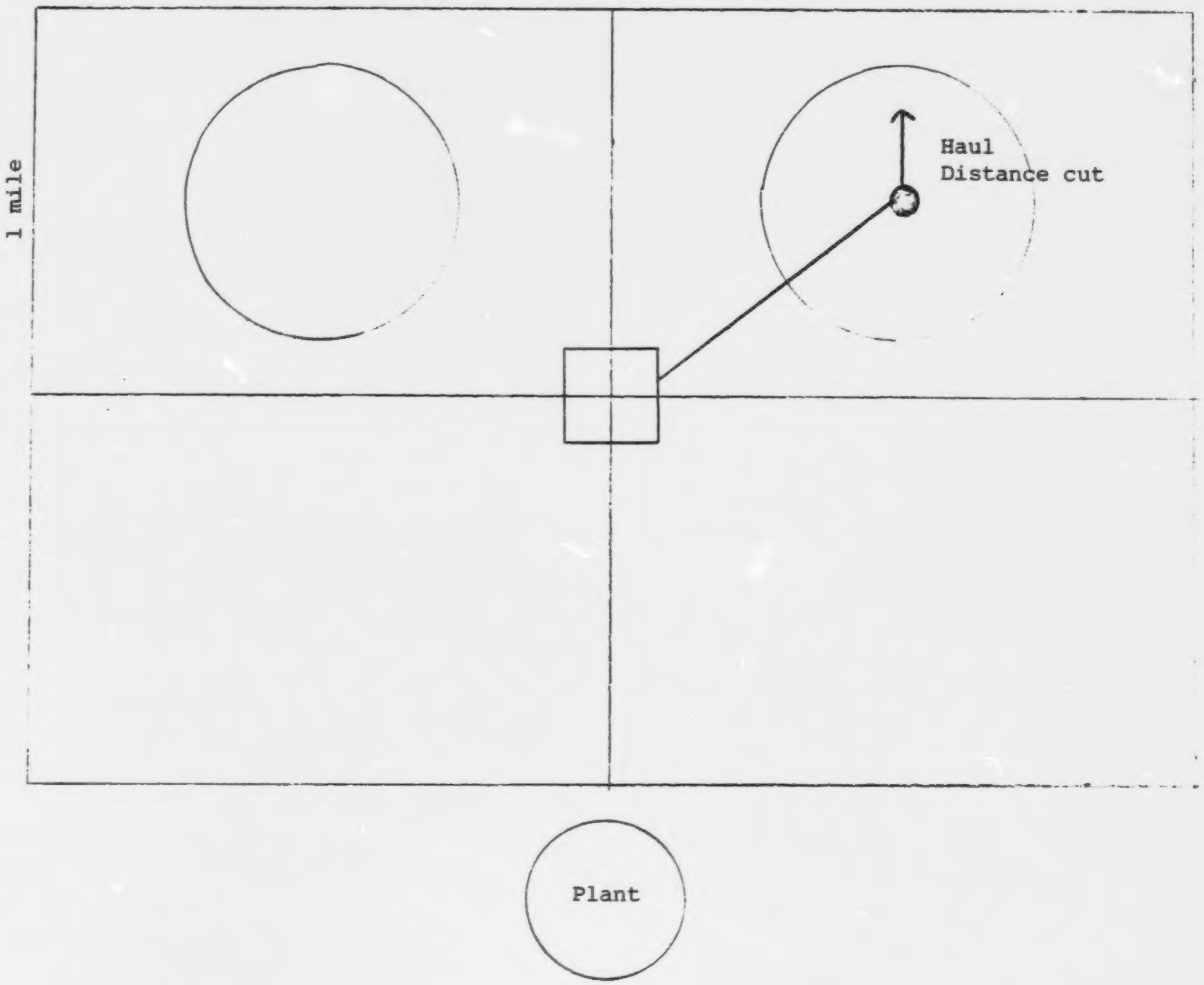
UTILITIES

1. Need developments in F.G. Desulphurization and Fluidized Bed Boilers.

2. For plants 50,000 BPD and up, a new tie-in to provincial grid is required.

3. Will require new gas lines for U/G's in F.M. Area.

D. Devenny's Flipchart
(Oct. 27/82)


1 mile
Haul
Distance cut
Plant

The Concept Development Team reconvened at 9:00 A.M. on Thursday, October 28, 1982.

Wirth suggested that our objectives for the deliberations of the day be:

- Finalize the Cases to be subsequently evaluated.
- Finalize the Technology Enhancement Possibilities.
- If time permits, commence evaluating Cases against the "Must" and "Want" criteria.

He further suggested we approach the achievement of these objectives by:

1. Having each of the groups display and review the results of their work of yesterday and the day before.
2. Using the Cases developed by one of the groups, finalize the Cases to be further evaluated.
3. Review the technology enhancement items that were identified.

Morris McClement and John Filby reviewed the material developed by their group. Morris started with a review of their group's ground rules that are covered in Pages 182, 183, 184. Those pages which cover Upgrading, Mining, Extraction and Utilities also addressed technology enhancement considerations.

Morris and John then reviewed the Cases they had developed and felt should be examined. The listing of those Cases appear on Pages 187 to 190.

Jim Guthrie advised that his group did not change the Case listing they had presented yesterday afternoon and had concentrated their further discussions on Technology, Enhancement Needs, and Economic Driving Forces.

It was noted the McClement Group had structured their Cases around size with technology considerations being sub-sets of the size Cases, whereas the Guthrie Group had selected their Cases based on technology with sizing considerations being sub-sets thereof. After considerable discussion it was decided on size as basis for selecting the Main Cases. It was felt that this would facilitate a more thorough evaluation of the modular approach and the scale-up in size through time.

CASES

Subset Cases

1. 25,000 BPD Integrated Plant (6)

   Mining Options - Mobile Equipment
   - Wheels

   Extraction - CHW

   Upgrading - H-Oil (Delivered)
   - Fluid Coking
   - Delayed Coking

2. 25,000 Bitumen Production only (2)

   Mining - Mobile Equipment
   - Wheels

   Extraction - CHW

   Upgrading - H-Oil in front of existing cokers (Unit must be sized for ~150% of planned bitumen production).

3. 50,000 Integrated Plant (4)

   Mining Options - (BWE
   (D.L.

   or Mobile Equipment

   Extraction - CHW

   Upgrading - Fluid Coking
   - H-Oil (Delayed)

4. 50,000 Remote Upgrading (2)

   Mining Options - as 3. Need - Pipeline/Diluent Optimization

   Extraction - CHW

   Upgrading - H-Oil (Delayed)

CASES

Subset Cases

5. 50,000 Bitumen Production to Syncrude/Suncor (2)

Mining)
) as 3.
Extraction)

Upgrading - H-Oil in front of existing cokers
(sized at 75,000 BPD)
- Add Coker ?

6. 50,000 Bitumen Production to Edmonton Refineries (2)

All as 4.

7. 100,000 Integrated (4)

Mining - Mobile Equipment
or (D/L
(Wheels

Extraction - CHW

Upgrading - Fluid Coking
- H-Oil (Coking)

8. 100,000 Remote Upgrader (2)

Mining - as 7. Optimize between
Pipeline/Diluent Production

Extraction - as 7.

Upgrading - H-Oil

9. 100,000 Bitumen Production piggybacked on SCL. (2)

Mining)
) as 7.
Extraction)

Upgrading - 150,000 B/D H-Oil in front of cokers
or 100,000 + New Coker ?

BUILD-UP CASES

(25 ---▶ 50 ---▶100)

Case 10 - Based on Case 1 as Starting Point

MINING

Truck/BWE ---▶ more of same

Truck ---▶ Convert to BWE/DL
(Trucks to O/B Removal)

EXTRACTION ---▶ more of same

UPGRADING

Start with Coker ---▶ add more
---▶ add H-Oil

Start with H-Oil ---▶ add more

Utility considerations become more important as -

Start ---▶ add Generation
No generation (esp. if convent to BWE/DL)

Case 11 - Starting with Case 2

Bitumen Production only
Flog to Syncrude/Suncor

MINING)
) same as Case 10
EXTRACTION)

UPGRADING

---▶ Flog more and more
i.e. Cases 5 B/U - 9 B/U

---▶ Add Coker

H-Oil Coker
Either @ 50 or 100 stage

Case 12 - Starting from Case 4

- Remote Upgrader

MINING - same as 4.

EXTRACTION - same as 4.
or add Retorting if available.

UPGRADING

---➡ add more Upgrading at Edmonton and optimize on diluent

---➡ add Coker and Pipeline Diluted Bitumen
(Special Case Retoring)

Case 13 - Starting with Case 6

Bitumen Production to Edmonton Refinery

Same as 4. B/U.

It was then decided to group the Cases into four categories; namely,

- Integrated Plants
- Remote Upgrading
- Piggybacking on Suncor/Syncrude
- Piggybacking on Existing Refineries

To simplify the process of developing a Matrix depicting the selected Cases, a Technology Legend, as shown on Page 192 was developed.

The group then proceed to develop the Matric of Cases. The Matrix of Selected Cases is shown on Page 193. During the development of the Selected Cases, it was concluded that the following list of items required further study and evaluation:

- Coke/Residue Disposition or Utilization
- Comparisons of Flexi/Fluid/Delayed Coking
- Transport/Pipeline Considerations for Remote Upgrading Cases require an analysis of the economics of Partial Upgrading vs Use of Diluent.
- Remote Upgrading Cases should examine both an Edmonton area location vs a Fort McMurray location.

TECHNOLOGY LEGEND

MINING

M1 Mobile Equipment

M2 DL/BW

M3 Short Haul - Separated Extraction

EXTRACTION

E1 Clark Hot Water Process (State of the Art)

E2 Retorting

UPGRADING (Primary)

R1 Fluid Coking

R2 Delayed Coking

R3 Flexi Coking

R4 H-Oil/L.C. Fining (Lo-Conversion)

R5 High Conversion (High Conversion) Hydro-Processing

R6 Visbreaking

R7 Hydrotreating

R11 Gasification/Fuel

R12 POX-H_2

R13 H_2 vis Stm. Ref.

R14 Burn "BTMS"

R15 FGD

UTILITIES

TRANSPORT

CASES TO BE EVALUATED

SIZE / GROUP	(a) 25,000 BPCD			(b) 50,000 BPCD			(c) 100,000 BPCD			(d) Staged Start '83 - Compl.'95? Build-up 25,000 - 100,000 BPCD		
	M	E	R	M	E	R	M	E	R	M	E	R
INTEGRATED (A)	M1 M2 M3	E1	R1 R2 R4/R2	M1 M2 M3	E1	** R1 R2 R4/R2 R4/R11/R12	M1 M2 M3 ⚠	E1	** R1 R2 R4/R2 R4/R11/R12	* ⚠	E1	* **
PIGGYBACK (S/S) (B)	M1 M2 M3	E1	R4	M1 M2 M3	E1	R4	M1 M2 M3 ⚠	E1	R4	--	--	--
REMOTE UPGRADING (C)	--	--	--	Best of (Bb)	E1	** R4/R2 R2	Best of (Bc) ⚠	E1	** R4/R2 R2	* ⚠ See Note	E1 E1/E2	* R7 **
PIGGYBACK (REF) (D)	Best of (Ba)	E1	R4	Best of (Bb)	E1	R4/R2 R2	--	--	--	--	--	--

NOTES:

1) Base Case - 100,000 BPCD using M2, E1, R1.
2) BPCD - Barrels per Calendar Day of Bitumen Feed to the upgrader.
3) * - For Cases Ad and Cd - Initial + Expansion Increments to be developed with appropriate process (technology selections).
4) ** - Coke/Residuum Disposition and/or Utilization needs to be examined.
5) ⚠ - Examine Merits of Single vs Multiple Mines.

- The potential shipment of diluted bitumen or partially upgraded bitumen to refineries outside of Alberta.

- The production of refined products or segregated components at the site of the Upgrader for shipment to other locations; i.e., West Coast, etc.

It was recognized that for Cases B, C, and D to become practical and viable, business arrangements and/or taxation rule changes would be required.

Speaking on behalf of the Jim Guthrie Group, John Porteous reviewed the results of the group's deliberations on Futuristic Cases that involve and require technology enhancements and developments. John covered the material shown on Pages 195 to 198 inclusive.

It was concluded that the next steps would be for Techman to:

- Analyze the various Cases identified using the Kepner-Tregoe approach.

- Do further work on the technology items identified.

- Conduct the special studies previously identified.

It was understood that only some of the above could be completed during Stage I.

SCHEME

Direct Retorting
(fixed location)

Lurgi

Taciuk

DRIVING FORCE

- Improved recovery at lower grades
- Less external energy supply
- Less integration
- Modular - stand-alone operation
- Operable - shut-down capability
- Relatively insensitive to feed grade and quality (fines)
- Dry tailings
- Early pit backfill and reclamation
- Shorter hauling of dry tailings

DISADVANTAGES

- Totally new, complex process
- Side effects unknown
    - emissions, waste sand heat and toxicity?
    - product variances?
    - safety of operation
- Delays in achieving rated capacity

CONCERNS

- Total heat loss greater - less energy efficient than other processes
- Self-sustainability of operations - wet/low grade feed
- Product characteristics, quality, predictability, specifications
- Large hot, black, fuming sand dunes
- Materials handling
- More equipment potential for tarsands

DEMONSTRATE COMMERCIAL APPLICATION

Demonstration scale pilot required

- solids/gas/liquid scale-up
- hydrocarbon yields and balance
- operating costs and reliability

SCHEME	DRIVING FORCE	DEMONSTRATE COMMERCIAL APPLICATION
High Conversion H-Oil	• Create more products of higher value • Create higher quality and lower sulphur, more suitable to modular • Maintenance, Manpower leveling advantages • More amicable to energy balance in a remote plant DISADVANTAGES • Not commercially proven for Athabasca bitumen • Operating experience limited • Potential start-up problems and achieving rated capacity delayed CONCERNS • Complementary to Fluid Coker • Handles feed variations better • Less sensitive to unit upset • Catalyst consumption • Product characteristics unpredictable in variations from specifications • Handling of residuals and ash	- Demonstration scale piloting required on Athabasca bitumen.

SCHEME	DRIVING FORCE	REQUIREMENTS
Enhanced Hot Water Process Tailings Sludge Improvement Example - RTR Process Sludge Reprocessing	ADVANTAGES Minimize current problems Minimize environmental impact Increase recovery of bitumen Tend to match government guidelines Decrease net energy consumption Decrease use of high-cost energy (i.e., steam)	Demonstrate (a) pilot stage - prove bottom line profitability as economic driving force
Bit. Recovery Improvements Example - RTR Process Kruyer (add on) Hot Water Mods. Syncrude 2-stage	DISADVANTAGES Cost of proving technology Potential for increased operability problems Impact on start-up of bitumen production Possible higher operating cost	
Energy Conservation Example - RTR Process Syncrude 2-stage Solvent assist on satellite operations		

SCHEME	DRIVING FORCE	REQUIRED
Fluidized Bed Combustion	ADVANTAGES Allow use of fuel Waste products as fuel ex. coke, pitch/resid. More efficient resource utilization Very amenable to handling of sulphur problems Less use of alternate fuels CONCERN Extent of removal of sulphur DISADVANTAGES ° Developing technical process and require boiler design modifications	Demonstration scale + estimating using planned fuel sources - operating history

It was decided to hold the next meeting of the Concept Development Team on November 24 and 25, 1982. The following items will be on the Agenda:

1. Comment on Minutes of Meetings held to date
2. Review of the Mega Project Write-up
3. Review of the Qualifer to the "Must" Statement
4. Review of Techman's Preliminary Evaluation of the Identified Cases
5. Review of Stage II Work Plans
6. Review of Draft Outline of Final Report

The meetings were adjourned.

A W Wirth

A.W. Wirth
Vice President & Project Director
TECHMAN ENGINEERING LTD.

APPENDIX B

MINUTES OF
THE CONCEPT DEVELOPMENT TEAM
MEETINGS

DECEMBER, 1982

MINUTES OF THE MEETINGS
OF THE
CONCEPT DEVELOPMENT TEAM

The entire Concept Development Team reconvened at 9:00 A.M. on Monday, December 6, 1982. Joining the group was Mr. Ralph Evans of the Energy Resources Conservation Board. Absent was Gerry Lewis-Steer.

Art Wirth welcomed Ralph to the group, who in turn introduced themselves; offered company affiliations and responsibilities.

The group concluded that the proposed discussion outline, attached to Art Wirth's letter of November 30, 1982 was acceptable. Wirth pointed out that Topic 3, Mobile Equipment Mining Scheme, would be dealt with in detail commencing at 3:00 P.M., this date, for those interested. A recap of the discussions would be presented on Tuesday morning, December 7, 1982 for those unable to attend the afternoon session.

PROPOSED DISCUSSION OUTLINE

	TOPIC	DISCUSSION LEADER
1.	A review of your comments on the Minutes of the Meetings held to date. The minutes were attached to our letter of November 15th.	A. W. Wirth
2.	A review of the highlights of meetings held with the two governments and governmental agencies since the last Concept Development Team meetings.	A. W. Wirth
3.	A presentation covering the Mobile Equipment (transport distances minimized) Mining Scheme developed by Techman.	C. J. Abbott
4.	A review of Techman's Preliminary Evaluation of Cases selected from a Matrix of Cases developed by the Concept Development Team.	D. M. McClement
5.	Preliminary Conclusions resulting from Stage I Work.	A. W. Wirth
6.	A review of the Proposed Stage II Work Program.	D. M. McClement
7.	A review of the draft outline of the Final Stage I Report.	D. M. McClement
8.	Other	et al

Topic 1. A review of your comments on the Minutes of the Meetings held to date. The Minutes were attached to our letter of November 15th.

Discussion on the Minutes of Meetings issued November 30, 1982 then took place. Comments were discussed in detail and have been incorporated in the minutes included in Appendix A of the Final Report. For reference purposes, a summary of the comments follows:

Page 22 - first paragraph - sentence commencing with "These processes ..... should read, "These processes are aimed at improving recovery, decreasing energy demand, and producing a dryer waste. The key objective of the improved extraction process is to eliminate progressive generation of expanding clay sludge".

Al Hyndman requested that a graph issued at the earlier C.D.T. meetings be included - SO_2 Emissions per Unit Crude Oil Production, to demonstrate effect of Environmental Regulations (Page 3).

Statement qualified to read: "particularly on small diameter pipelines. Those large diameter union jobs have shown decided increases over the last 12 months. It is recognized that over the last decade Canadian pipeline costs have indeed spiraled at a pace greater than other industrial sectors".

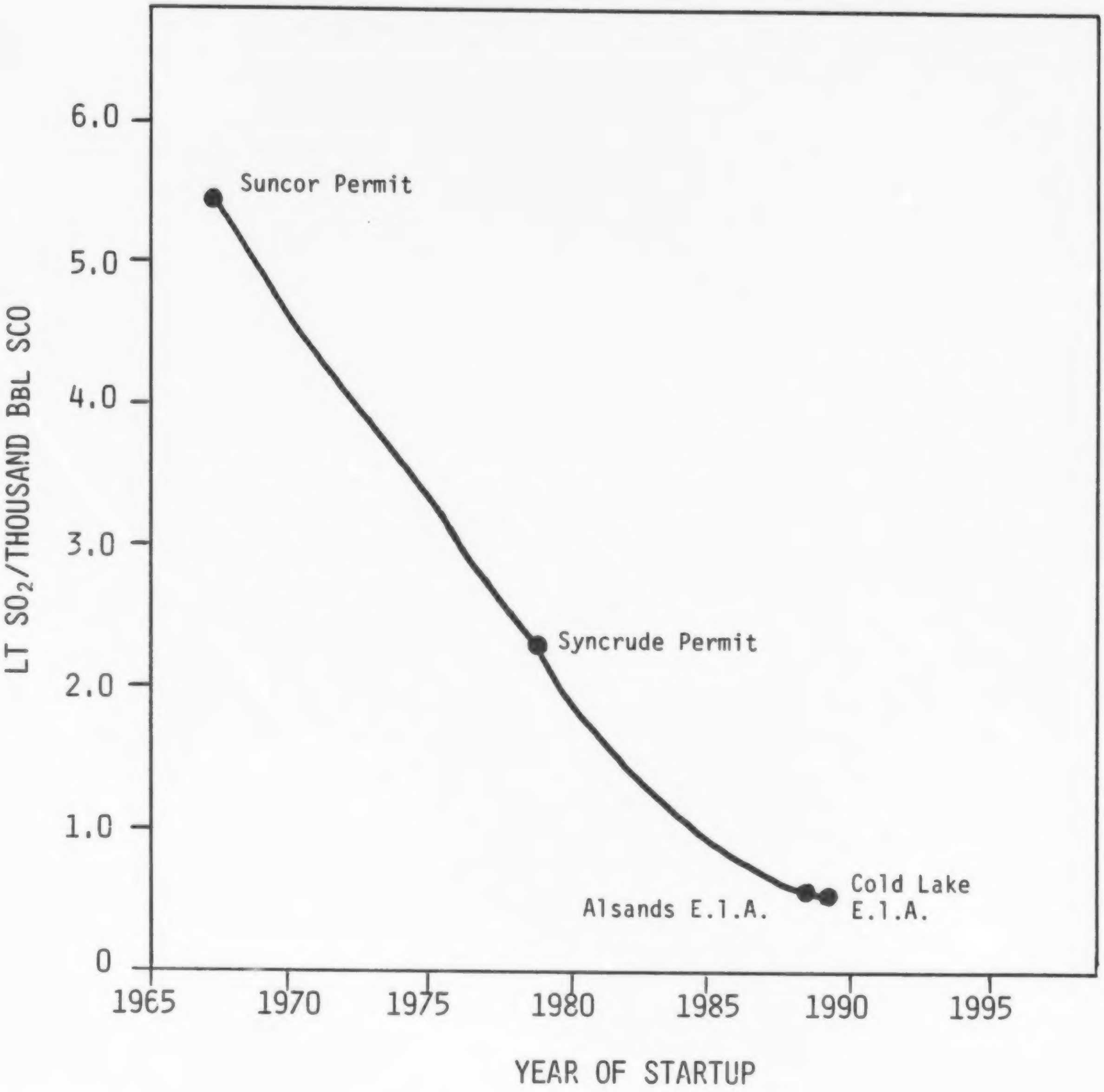
Art Wirth agreed with the above and pointed out that the Government of Canada has expressed concern about pipeline costs in the pipeline industry, compared to U. S. Mr. Chrietien has commissioned a one man study to look into what is wrong with the Canadian pipeline industry.

All references to lease life to be synchronized at 25 years. (E. Yildirim).

Page 39, Item 7 covered a lot of different items but some items were not captured. Tom McCann has put together the following short explanatory paragraph expanding on the items that were discussed. (J. Filby).

The grease pencil curve on Figure 7.4 branching upwards off the "Plus Inflation" curve was added to illustrate likely actual costs when managability factors are considered. The problems of mega-project management particularly with a number of owners was discussed and there was some agreement that unit capital costs stay constant or go up above a certain size. However, the difficulty of quantifying this effect was also noted. The larger exposure of mega-projects, as compared to smaller projects, was also noted as greatly increasing the managability problem.

While a dashed line is shown on Figure 4 for a possible non-union scenario, this had been drawn up for an upgrading only case and is not applicable to tarsands plant of any viable size.



SO_2 EMISSIONS PER UNIT OF CRUDE OIL

Topic 2. A review of the highlights of meetings held with the two governments and governmental agencies since the last Concept Development Team meetings.

Art Wirth reviewed his discussions with the Provincial Government, ERCB, AOSTRA and Bruce Rawson, Regional Economic Coordinator with the Federal Government.

Wirth then summarized the presentation by Messrs. Wirth, Jaycock and McClement to an assembly of Federal Government Departments in Ottawa.

The results from the Provincial meeting is that we are fortunate to have Ralph Evans appointed to the Concept Development Team on behalf of the Energy Resources Conservation Board.

The purpose of the presentation in Ottawa was to make them aware of what we were doing in Stage I and to review the preliminary conclusions. The feedback from these sessions and subsequent to the sessions was favourable.

The Chairman then introduced Topic 4 in keeping with the plan to cover Topic 3 later in the afternoon.

Topic 4. A review of Techman's Preliminary Evaluation of Cases selected from a Matrix of Cases developed by the Concept Development Team.

Wirth suggested it would be best if he tabled and reviewed with the group the preliminary conclusions talked about in Ottawa so that the group could look at the material as part of Topic 4 and view it in that context; namely, do the results of Techman's analysis lead the Concept Development Team to the same conclusions?

Wirth then summarized the preliminary conclusions as discussed in Ottawa:

- Stage I work provides a base of information and knowledge for the selection of cases and technologies to be evaluated in Stage II. Provides direction for Stage II work.
- Smaller size is attractive
  - don't know how small is best
  - don't know how attractive
- Have developed a mining scheme based on a modular concept, using mobile equipment with transport distance minimized that has good economic potential and is particularly applicable to smaller sizes and is readily expandable. Needs to be developed and examined in more detail.

- Staged - buildup cases are economically attractive. Best initial size and the buildup increments to be determined.

- Potential technology enhancements in mining, extraction and upgrading have been identified and need further examination.

- New mining and extraction facilities supplying bitumen to Suncor, Syncrude or certain existing Edmonton refiners have good potential. Estimating capital and operating costs require participation of the owners. Work program and budget for Stage II does not provide for a detailed evaluation of these cases. When mining and extraction work is complete for remote upgrading cases, we propose to solicit their interest and attempt to have them participate in studies specific to their lease site and operations.

- 6 main cases should be evaluated in detail during Stage II, with emphasis on mining schemes and with extraction and upgrading technologies being evaluated because of heat and other integration, and coke/residuum disposition considerations. The 6 main cases are:

  A) Grass Roots Integrated Plants

  1. Small - probably about 15 - 25 KBPCD
  2. Large - 100 KBPCD (Base Case) probable with modular approach in mining
  3. Staged - from small to large

  B) Grass Roots Plants with Remote Upgrading

  As in "A"

McClement described the nine (9) cases selected by Techman, referring to the viewgraph "Description of Cases", (Pages 6, 7, 8). He passed out copies of the Selected Case Summary, Page 9, for review. At this point there was a lengthy general discussion on single trains for bucketwheels, extraction plant, fluid cokers, etc. Service factors on small vs large plants were also discussed at length and the whole question of the relationship between service factor, multiple process trains and size was tabled.

McClement summarized the discussion by observing that, for purposes of Stage I, the considered assumptions which Techman developed for service factor and the number of trains would be maintained. Time and scope constraints would not permit further evaluation at this point.

DESCRIPTION OF CASES

1. BASE CASE

    100,000 BBL./DAY BITUMEN FEED

    MINING - BWE, BWR, DRAGLINE

    EXTRACTION - 3 TRAINS CLARK HOT WATER PROCESS

    UPGRADING - 2 TRAINS FLUID COKING

2. 100,000 BBL./DAY BITUMEN FEED

    MINING - MOBILE EQUIPMENT

    EXTRACTION - 3 TRAINS CLARK HOT WATER PROCESS

    UPGRADING - 2 TRAINS FLUID COKING

3. 25,000 BBL./DAY BITUMEN FEED

    MINING - MOBILE EQUIPMENT

    EXTRACTION - SINGLE TRAIN CLARK HOT WATER PROCESS

    UPGRADING - SINGLE TRAIN FLUID COKING

4. 25,000 BBL./DAY BITUMEN FEED

    MINING - BWE, BWR, DRAGLINE

    EXTRACTION - SINGLE TRAIN CLARK HOT WATER PROCESS

    UPGRADING - SINGLE TRAIN FLUID COKER

CONT'D

DESCRIPTION OF CASES (CONT'D.)

5. 25,000 BBL./DAY BITUMEN FEED, BUILDING TO 100,000 BBL./DAY BITUMEN FEED

MINING - MOBILE EQUIPMENT BUILDING TO EXPANDED MOBILE EQUIPMENT

EXTRACTION - SINGLE TRAIN CLARK HOT WATER PROCESS INITIALLY BUILDING TO THREE TRAINS IN EXPANDED MODE

UPGRADING - SINGLE TRAIN FLUID COKER INITIALLY, SUPPLEMENTED BY RESIDUUM HYDROCRACKING IN EXPANDED MODE

6. 25,000 BBL./DAY BITUMEN FEED, BUILDING TO 100,000 BBL./DAY BITUMEN FEED, UPGRADER LOCATED IN FORT SASKATCHEWAN

MINING - MOBILE EQUIPMENT BUILDING TO EXPANDED MOBILE

EXTRACTION - SINGLE TRAIN CLARKE HOT WATER PROCESS BUILDING TO THREE TRAINS IN EXPANDED MODE

UPGRADING - SINGLE TRAIN DELAYED COKING INITIALLY, BUILDING BY ADDITION OF RESIDUUM HYDROCRACKING

7. 50,000 BBL./DAY BITUMEN FEED

MINING - MOBILE EQUIPMENT

EXTRACTION - SINGLE TRAIN CLARK HOT WATER PROCESS

UPGRADING - SINGLE TRAIN FLUID COKER

CONT'D

DESCRIPTION OF CASES (CONT'D.)

8. 50,000 BBL./DAY BITUMEN FEED, UPGRADER LOCATED IN FORT SASKATCHEWAN

MINING - MOBILE EQUIPMENT

EXTRACTION - 2 TRAINS CLARK HOT WATER PROCESS

UPGRADING - SINGLE TRAIN DELAYED COKING PLUS RESIDUUM HYDROCRACKING

9. 100,000 BBL./DAY BITUMEN FEED, UPGRADER LOCATED IN FORT SASKATCHEWAN

MINING - MOBILE EQUIPMENT

EXTRACTION - 3 TRAINS CLARK HOT WATER PROCESS

UPGRADING - SINGLE TRAIN DELAYED COKER PLUS RESIDUUM HYDROCRACKING

82-11-30

SELECTED CASE SUMMARY

LEGEND:
CHW - CLARK HOT WATER
BPU - BITUMEN PREPARATION UNIT
F.C. - FLUID COKING
D.C. - DELAYED COKING
H-OIL - LOW CONVERSION H-OIL HYDROCRACKING
BWE - BUCKETWHEEL EXCAVATOR
T/S - TRUCK & SHOVEL

NOTES: (1) SULPHUR & COKE - NO COST, NO VALUE
(2) FUEL PURCHASE - NATURAL GAS; DIESEL FOR T/S

CASE	CAPACITY K-BPCD (BITUMEN)	STAGING	CONFIGURATION	MINE			EXTRACTION			UPGRADING				UTILITIES	REMARKS
											TRAINS				
				SCHEME	TRAINS	SPECIAL FEATURES	SCHEME	TRAINS	SPECIAL FEATURES	SCHEME	PRIMARY	SECONDARY	SPECIAL FEATURE	SPECIAL FEATURES	
1	100	1	INTEG	BWE/DL	3		CHW	3		FC	2	2		SELF GEN. OF STEAM & POWER	
2	100	1	INTEG	T/S	-		CHW	3		FC	2	2		SAME AS CASE 1	
3	25	1	INTEG	T/S	-		CHW	1		FC	1	1		SAME AS CASE 1	
4	25	1	INTEG	BWE/DL	1		CHW	1		FC	1	1		SAME AS CASE 1	
5	25 100	2	INTEG	T/S	-		CHW	1 3		25-FC 100-H-OIL/FC	1-F.C. 2-H-OIL	1		SAME AS CASE 1	
6	25 100	2	REMOTE	T/S	-		CHW	1 3		25-DC 100-H-OIL/DC	1 1-D.C. 2-H-OIL	1	BPU AT SITE	PURCH. POWER; L.P. STEAM AT SITE	DILUENT PIPELINE
7	50	1	INTEG	T/S	-		CHW	2		FC	1-FC	2		SAME AS CASE 1	
8	50	1	REMOTE	T/S	-		CHW	2		H-OIL/D.C.	1-D.C. 2-H-OIL	2	BPU AT SITE	SAME AS CASE 6	DILUENT PIPELINE
9	100	1	REMOTE	T/S	-		CHW	3		H-OIL/D.C.	1-D.C. 3-H-OIL	3	BPU AT SITE	SAME AS CASE 6	DILUENT PIPELINE

Topic 4. Continued

He assured the group that these very important factors would be evaluated in depth during Stage II.

Capital and Operating Costs (in constant 1982 dollars) used in the economic model were then reviewed for the nine cases. It was observed that the estimates are very order-of-magnitude in the -5% to +50% accuracy. In addition, the estimates for the remote cases (6, 8 and 9) are very "soft" because more technical work and optimization is required before rigorous analysis can be done.

McClement continued by presenting the results of Techman's financial analysis, as measured by two key parameters (Page 14):

- maximum Financial Performance
- maximum Financial Exposure

These measurements are reflected in the three attachments (Pages 15, 16, 17) Financial Performance and Exposure, Payback Period, Capital and Operating Costs.

Techman's analysis, using K-T method, was reviewed and concluding summary issued:

K-T Sheets - "Evaluation of Cases against "Wants", Page 18.

Conclusions on Financial Data Base indicated preference for small and medium size plants and also buildup cases (i.e. Cases 3, 5, 6, 7, 8).

The group then went through other 8 points and scored them.

Technical Risk - highest scores went to integrated plants using tested technology ∴ less technical risk.

Operability - integrated plant looked best.

Expandability - small plants are more acceptable. The ones that are designed as expandable are best of all.

After considerable discussion on "expandability" it was concluded that this is difficult to quantify - and in practical terms expandability must be considered as a stated objective during initiation of a specific project, and is really not so much a question of achieving a larger size as in preserving future options related to size and technology.

ECONOMIC CRITERIA

USED IN THE EVALUATIONS

- MAXIMUM FINANCIAL PERFORMANCE

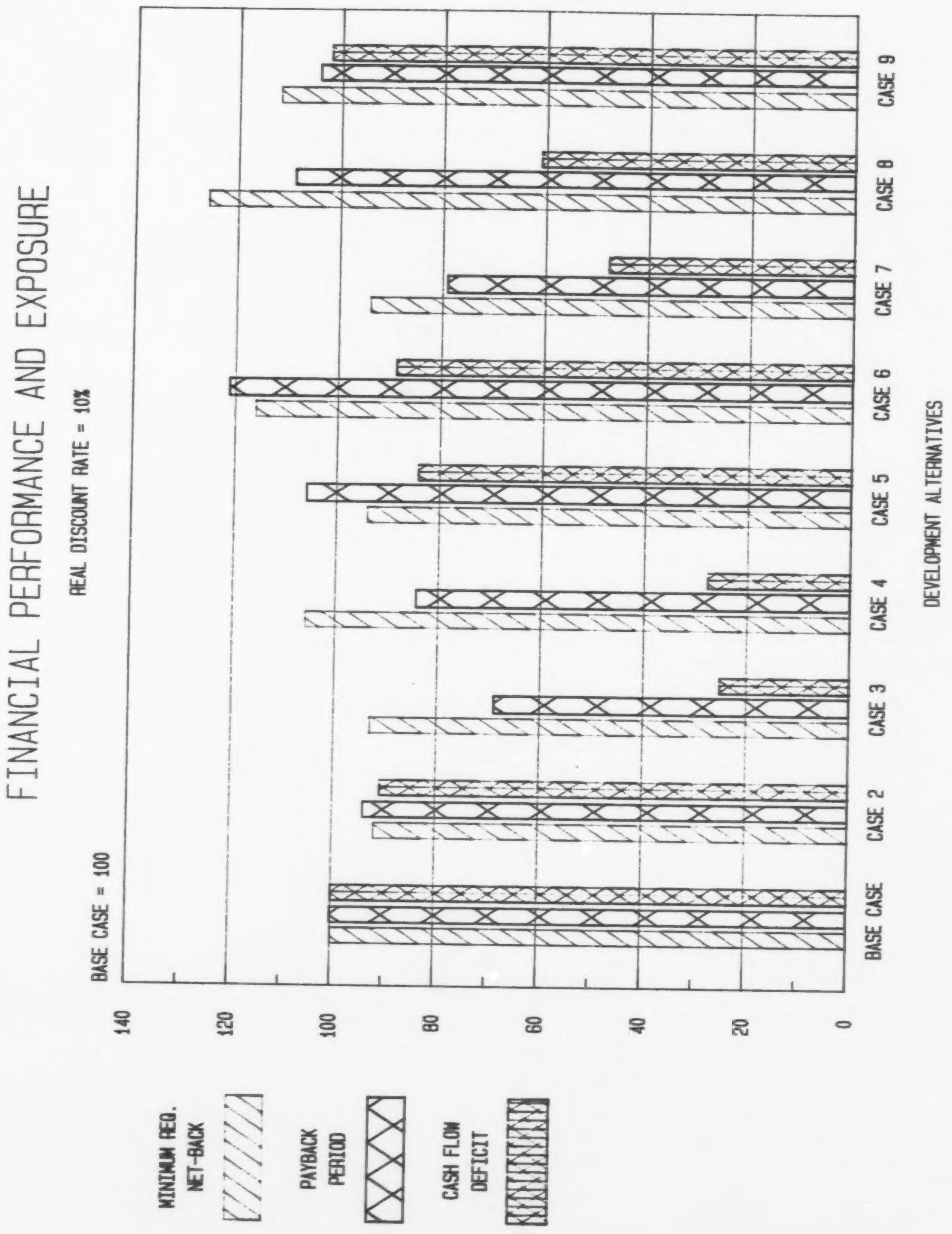
  MEASURED BY REQUIRED NET BACK ($BBL) FOR VARIOUS RATES OF RETURN.

  CASES REQUIRING THE LOWEST NET BACK ARE BEST.

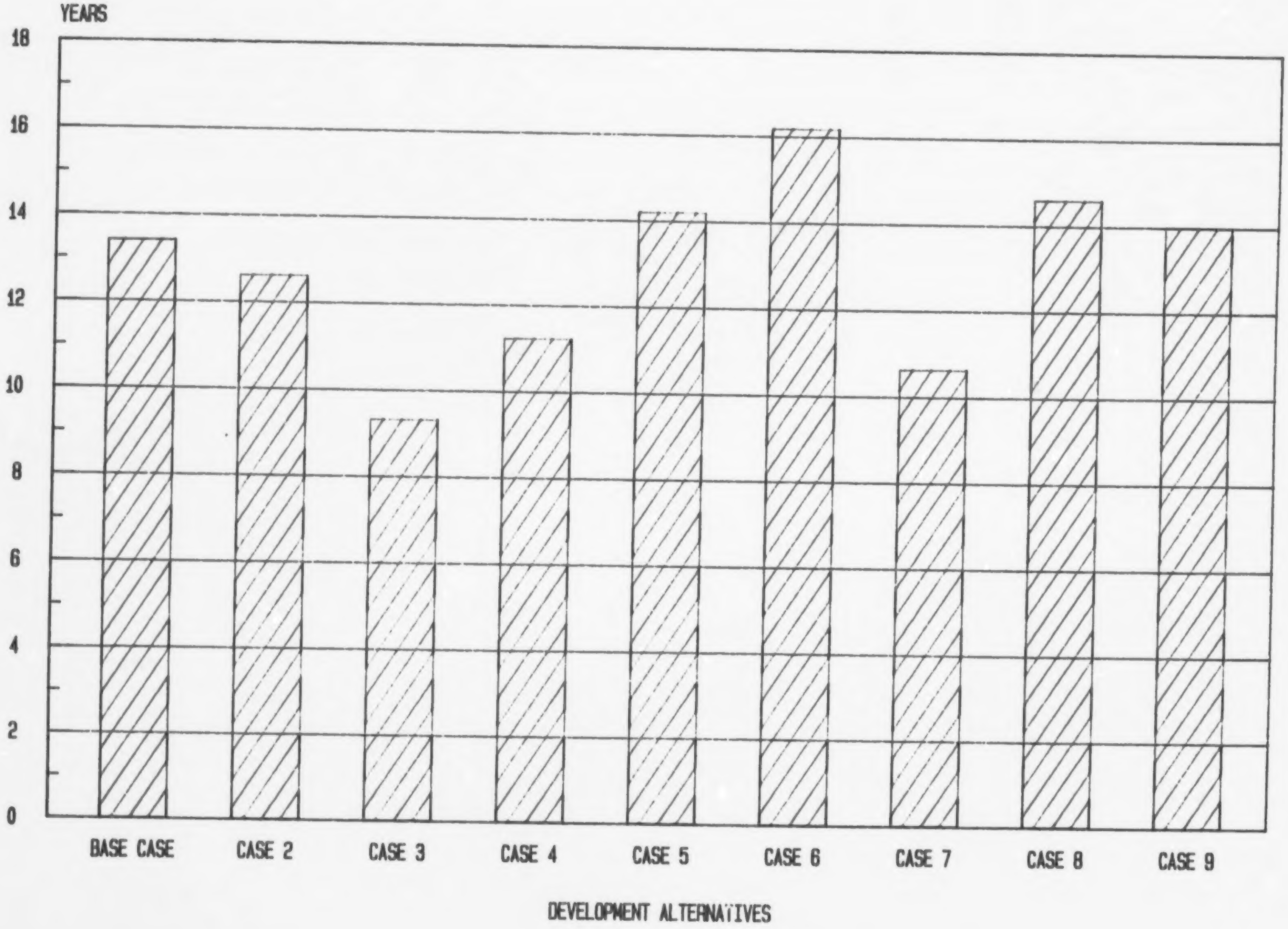
- MINIMUM FINANCIAL EXPOSURE

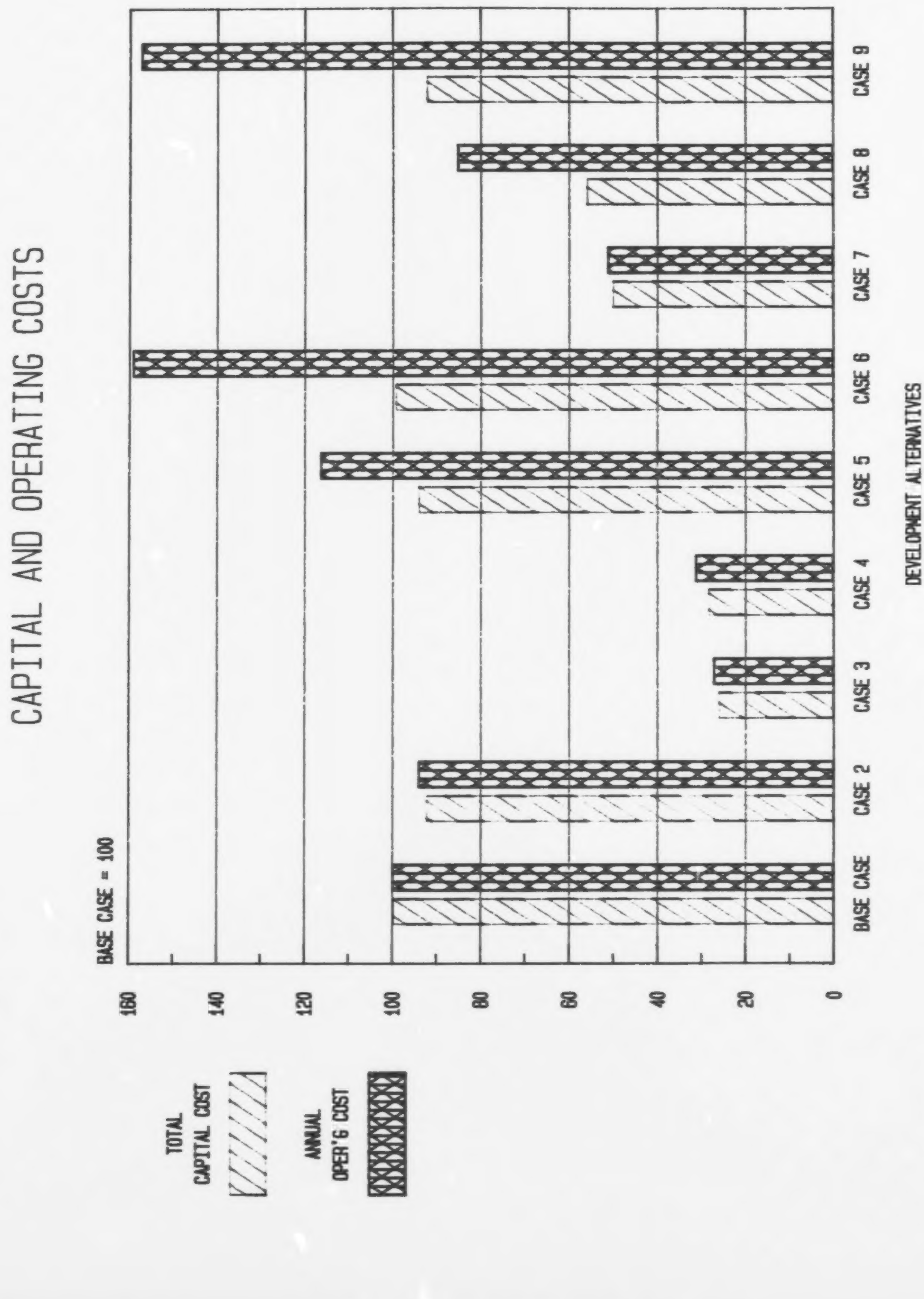
  MEASURED BY:

  - PAY BACK PERIOD
  - LOWEST NEGATIVE CUMULATIVE CASH FLOW


FINANCIAL PERFORMANCE AND EXPOSURE
REAL DISCOUNT RATE = 10%
BASE CASE = 100
140
120
100
80
60
40
20
0
BASE CASE
CASE 2
CASE 3
CASE 4
CASE 5
CASE 6
CASE 7
CASE 8
CASE 9
DEVELOPMENT ALTERNATIVES
MINIMUM REQ. NET-BACK
PAYBACK PERIOD
CASH FLOW DEFICIT

PAYBACK PERIOD





CAPITAL AND OPERATING COSTS

EVALUATION OF CASES AGAINST 'WANTS'

WANTS	CDT WEIGHT	CASE 1		CASE 2		CASE 3		CASE 4		CASE 5		CASE 6		CASE 7		CASE 8		CASE 9	
		WT	S	WT	S	WT	S	WT		WT		WT		WT		WT		WT	
MINIMUM TECHNICAL RISK	8	8	64	8	64	10	80	8	64	6	48	6	48	9	72	7	56	6	48
MAXIMUM OPERABILITY	8	8	64	9	72	10	80	4	32	6	48	6	48	9	72	7	56	6	48
MAXIMUM EXPANDABILITY	4	1	4	2	8	7	28	5	20	10	40	9	36	5	20	5	20	3	12
OPTIMUM NATURAL RESOURCE UTILIZATION	4	4	16	6	24	6	24	4	16	10	40	8	32	6	24	8	32	8	32
MINIMUM ENVIRONMENTAL IMPACT	4	5	20	6	24	10	40	8	32	8	32	8	32	7	28	8	32	8	32
MINIMUM ADMINISTRATION	4	3	12	4	16	10	40	9	36	7	28	6	24	6	24	6	24	4	16
MINIMUM ADVERSE SOCIO ECONOMIC, IMPACT	2	3	6	4	8	10	20	9	18	7	14	9	18	6	12	8	16	7	14
MAXIMUM CANADIAN BENEFITS	2	7	14	7	14	7	14	7	14	9	18	10	20	7	14	7	14	7	14
SUB-TOTAL - NON-FINANCIAL			200		230		326		232		268		258		266		250		216
FINANCIAL PERFORMANCE	10	7	70	10	100	10	100	5	50	9	90	3	30	9	90	1	10	4	40
MINIMUM FINANCIAL EXPOSURE	9	4	36	5	45	10	90	8	72	5	45	4	36	8	72	5	45	4	36
SUB-TOTAL - FINANCIAL			106		145		190		122		135		66		162		55		76
GRAND TOTAL			306		375		516		354		403		324		428		305		292

(CORRECTED COPY 82-11-29)

Topic 4. Continued

It was then agreed that rather than buy into Techman's analysis. the Concept Development Team should perform an independent K-T analysis of the selected cases.

Wirth suggested that three groups be formed to go through the cases in relationship to the "wants" that were established. This is a necessary step to take but first one must understand objectives and tasks of Stage II to be in a better position to evaluate the cases.

It was therefore concluded that we should review Stage II and get to Topic 6 and this will allow everyone to be in a better position to evaluate the cases.

Topic 6. A review of the Proposed Stage II Work Program.

McClement passed out copies of the "Work Statement". He also showed a viewgraph "Stage 2 Objectives" and they are attached, Page 20 - 29.

Additional information passed out for discussion included Engineering Manhours, Page 30; Task Schedule, Page 31; and the two Organization Charts envisioned for Stage II, Pages 32 and 33.

It was noted that the continuation of involvement on the part of the Concept Development Team will be required, but reconstituted as the "Project Advisory Committee" (PAC). The manhours for the PAC activities were not included in the enclosed estimates. It was concluded that the PAC group would convene at "milestone" points during the course of Stage II.

Some specific points were raised in connection with Stage II work:

- Al Hyndman suggested that more emphasis should be placed on the quantity and detail of the work by reducing the number of cases selected and focusing more on those cases.
- Erdal Yildirim emphasized the need to test the impact of size, and separately the impact of number of trains on plant operability and reliability.

WORK STATEMENT

1. List all schemes selected for evaluation. This list will include all schemes selected by Task 4 of Stage 1 of the study, augmented or adjusted by any later intelligence during the completion of Stage 1.

   Divide schemes according to type, as follows --

   - Integrated (Interconnected from a physical and energy viewpoint)
   - Distributed (Non-integrated--local upgrader)
   - Remote upgrader (Upgrader located some distance away)
   - Build-up (Plant goes into operation at small scale and subsequently expands)
   - Piggybacked (new facility synergistically connected to an existing oil sands plant or refinery)

2. Determine appropriate service factors for various component processes and make provisional process train assumptions to facilitate preliminary sizing of the Extraction and Upgrading Units. In performing this task, the following factors should be taken into account:

   - Equipment Redundancy
   - Process Reliability
   - Maintenance Requirements
   - Storage of Intermediate Products
   - Unit Turn-down

3. Review available geological data for mineable tar sands area and develop representative geological profiles upon which to base mining plans. The geological column should be representative and provide for normally encountered problems. Items to be considered include the following:

   - Overburden Depth
   - Ore body depth
   - Bitumen Saturated Sand (grade and thickness)
   - Lean Tar Sand and Clay (grade and thickness)
   - Inclusions (indurated siltsone)

3. Continued

   - Ore body variability, both areally and with depth

   - Aquifers

   Determine the applicability of the column and develop additional data, if required. (The selected scheme or schemes are to have substantial general applicability, and be specifically applicable to at least one lease).

4. Develop design of selected mining schemes at each size, completely scoping and sizing equipment, to develop the following data for each scheme:

   - Yearly Cost Schedule (contract, capital and operating)

   - Service Factors

   - Energy requirements, source and type

   - Illustrate the operability of the mining schemes with mining schematic drawings (cross sections and plans) and material balances schedules.

   - Evaluate impact of selective mining on mining, tailings disposal and extraction costs

   - Include tailings disposal as an integral part of mining planning

5. Develop size limitations and optimum sizes, if such exist and are different from selected cases, for various mining schemes, and develop concomitant cost data. The output of this task will be an optimized mining technology over all size ranges and the cost function corresponding to size and technology, considering both operating and capital costs.

6. List proprietary Extraction technologies identified for evaluation and contact licensors/developers to obtain current available data. Data required will include the following:

   - State of development of the technology and schedule for commercial demonstration if unproven

   - Ability to process varying feed qualities

   - Required feed conditioning

   - Energy and utilities requirements

   - Recovery efficiencies with different feed grades

6. Continued

- Quality of product
- Nature and quantity of tailings
- Capital and operating cost data, basis and source of cost data
- Size limitations and basis for sizing parameters
- Anticipated or demonstrated service factor

7. Develop Preliminary Process Scheme for Extraction units at each size selected, taking into account service factors and process train assumptions. The data developed should include the following:

- Energy and Material Balances
- Product Quality
- Quantity and Nature of Tailings Streams
- Requirements for Chemicals and Solvents
- Capital and Operating Costs
- Size Exponent of Capital Cost at each size

8. Identify Extraction Processes whose state of development precludes their consideration in the short-run, but whose potential advantages are attractive in the long-run. Quantify the driving force for development and the probable development schedule. Consideration should be given to the following:

- Potential Economic Advantages -
    - Lower Capital Costs
    - Lower Operating Costs
    - Shorter Project Schedule
    - Greater Bitumen Yields
- Potential Operability Improvements -
    - Better Service Factor
    - Simpler Operation
    - Better Performance on Low-Grade Ores
- Potential Mitigation of Adverse Environmental and Socio-Economic Impacts -
    - Better Resource Utilization
    - Better Quality Tailings
    - Reduction in Tailings Pond Area

9. List proprietary upgrading technologies identified for evaluation and contact licensors to obtain current, available data. Data required will include the following:

   - State of development of the technology (Pilot Scale, Demonstration Scale, Commercially Proven)
   - Experience with extracted Athabasca bitumen
   - Yield data as demonstrated or predicted
   - Product quality data
   - Energy balances and utility requirements
   - Capital and operating costs data and basis and sources of cost data
   - Size limitations and basis for sizing parameters
   - Suggested overall processing scheme
   - Service factor

   The technologies considered should cover both primary and secondary upgrading and ancillary units such as hydrogen production units, sulfur recovery, etc.

   In most cases, the data will be available as sales data from licensors: In some cases, a non-disclosure agreement will be required to access required information.

10. Develop Preliminary Process Scheme for Upgrading units at each size selected, including both Primary and Secondary Upgraders and Ancillary Units, and taking into account the service factors of various units and process train assumptions. The following data should be developed:

    - Energy and Material balances
    - Product qualities
    - Capital and operating costs
    - Size Exponent of Capital Cost at each size

11. For each size and type (i.e. - Location) of Primary Upgrader, select the Optimal Upgrading Scheme from those developed in Task 4, if there is an obvious basis for the choice. For example, a choice between fluid, flexi, and delayed coking could probably be made at this time. If the trade-offs are between capital and operating costs or if there are significant differences in energy balances which could affect integration with the Extraction Unit, carry competing technologies into the Optimization and Evaluation stage.

12. Identify Upgrading processes whose state of development precludes their consideration for the short-run, but whose potential advantages are attractive in the long-run. Quantify the driving force for development and the probable development schedule. Consideration should be given to the following:

    - Potential Economic Advantages -
        - Lower Capital Costs
        - Lower Operating Costs
        - Shorter Project Schedule
        - Greater Product Yield
    - Potential Operability Improvements -
        - Better Service Factor
        - Simpler Operation
        - Requires Fewer Ancillary Units
        - Operationally Flexible
        - Low Maintenance Requirements
    - Potential Mitigation of Adverse Environmental and Socio-Economic Impacts -
        - Fewer by-products
        - Fewer and less objectionable emissions
        - Better resource utilization
        - Less intense utilization of social resources
        - Creation of employment and business opportunities

13. Develop Design of Utilities and Offplot Facilities for the various types and sizes of development scenarios and develop cost data for all of the following:

    - Tankage
    - Maintenance Facilities, Mining and Process Area
    - Service buildings
    - Water and Waste treatment facilities
    - Site improvements - grading, roads, fencing

13. Continued

- Steam and power generation
- Product and natural gas pipelines

14. Develop Preliminary Plant operating cost data for the various types and sizes of plants selected. Consider the following cost elements:

- Operating Labour
- Maintenance Labour
- Catalysts and chemicals
- Parts and supplies
- Fuel and Power

15. Develop total schemes for the various sizes and types of plants, including utilities and energy balances, matching of service factors, etc. Review the provisionally selected sizes, considering the size/cost function of the Mining Designs and the size exponent of cost for Extraction and Upgrading, to determine if the sizes selected are sub-optimum. If selected sizes are not optimal, select optimal sizes, guided by the cost functions.

16. Develop Process Design for all selected overall schemes taking into account any new size considerations arising out of Task 15 and Process sub-optimization developed in Task 11. Data available as output from this task, should include, for each size and type:

- Overall Process Flow Diagram
- Energy and material balances
- Project development schedule
- Product qualities
- Utilities requirements and sources
- Probable Project Execution Plan, to define infrastructure requirements and impacts
- Operating and Capital Costs and Revenues
- Cash Flow Profile
- Environmental Impact

16. Continued

- Socio-Economic Impacts
- Resource utilization
- Canadian and regional industrial benefits
- Significant non-economic and non-technical differences from a typical mega-project, including
  - Quality of facilities (redundancy, sparing, design life, service factor)
  - State of Development of Technology
  - Disposal of by-products
  - Employee related infrastructure

17. Using the Cost Data for each scheme, develop two comparators for economic performance, financeability and financial risk, using Techman's economic model. Run sensitivity parametrics and put estimates on a probabilistic basis using risk analysis techniques.

18. Using all data developed in Task 16 and 17, test each remaining case against the viability criteria established during Task 4 of Stage 1:

- Financial Performance
- Minimize Financial Exposure
- Maximize Operability
- Minimize Technical Risk
- Maximize Expandability
- Minimize Adverse Environmental Impact
- Maximize Resource Utilization
- Minimize Administrative Complexity
- Maximize Canadian and Regional Benefits
- Minimize Adverse Socio-Economic Impacts

Rank the cases within each type --- i.e. by Permutations of size and technology.

19. Select the best scheme (s), taking into account the following:

    - Development Timetable
    - Ranking of Schemes
    - Degree of development of Selected Technologies
    - Driving force for development of "soft" technologies

20. Review results with Project Advisory Committee, rationalizing results vs viability criteria, reviewing weights within the decision algorithm and recycling as required to arrive at the agreed selection of schemes.

21. Complete documentation of the selected scheme (s) including all relevant data, some of which must be developed and some of which was previously developed in the Concept Development Team meetings, such as:

    - Required business environment for the advancement of the selected project, including all matters of policy and economics, stability of the business environment, etc.
    - Required technology developments to support selected schemes and driving force for all identified potential enhancements.
    - Areas where additional study or development work is required -- possibly demonstration scale operations --- beyond the scope of this study.

22. Prepare final report, including the following:

    - Documentation of selected scheme (s) including business environment
    - Analysis of cases
    - Outline of all cases examined
    - Suggested future enhancements and required technology advancements including driving force for all identified potential enhancements
    - Required additional study work or pilot plant work

23. Present results to audiences selected by the Government. This task includes preparation of required presentation material.

24. This task is to cover Project Management of the study including:

- Project Management
- Project Services
- Cost and schedule control
- Project Accounting
- Client Liaison
- Periodic Progress reporting

STAGE 2 OBJECTIVES

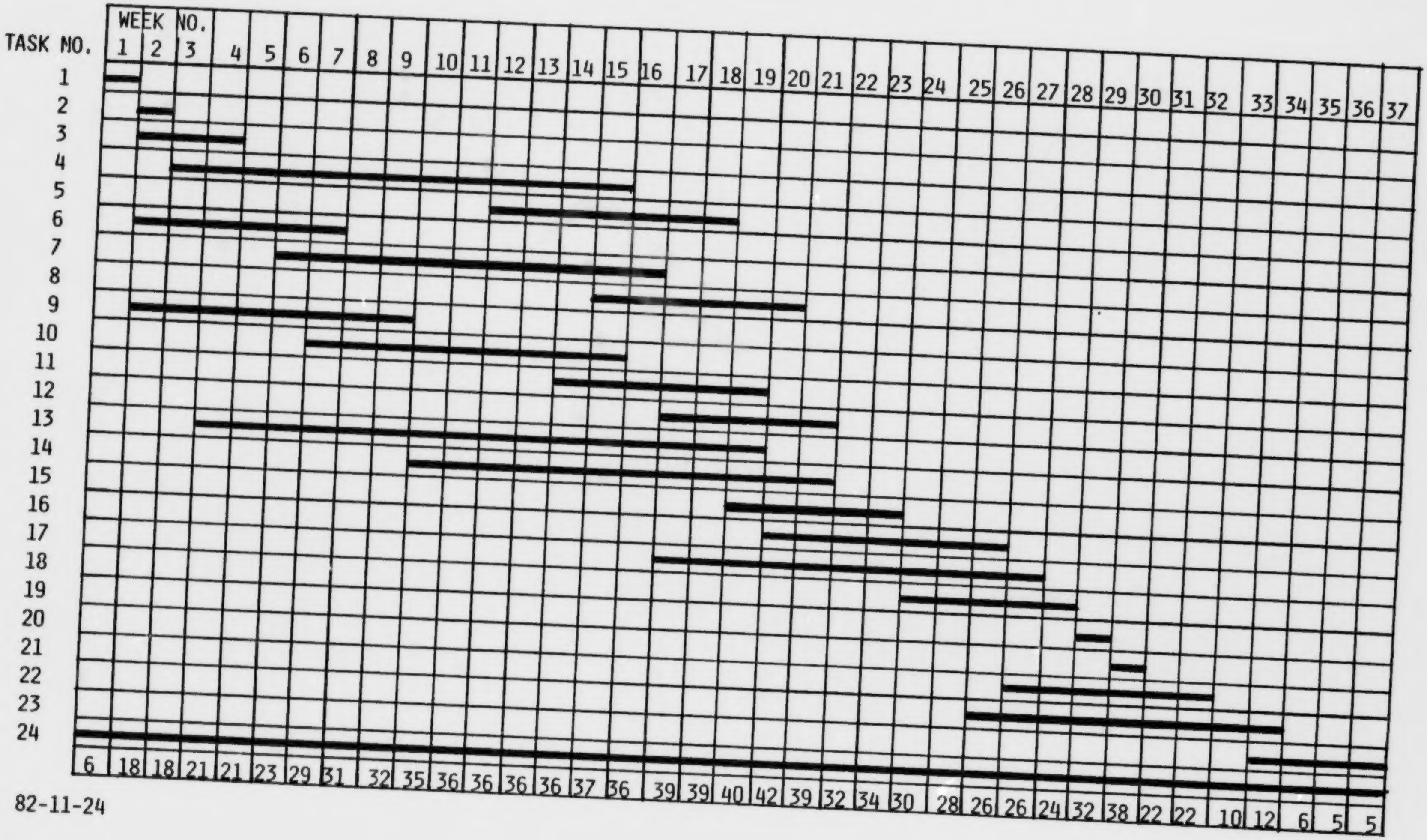
1. TO COLLECT COST AND OPERATIONAL DATA FOR SELECTED PROCESSES.
2. TO EVALUATE ALTERNATIVE MINING SCHEMES.
3. TO EVALUATE ALTERNATIVE EXTRACTION SCHEMES.
4. TO INTEGRATE SELECTED SCHEMES INTO COMPLETE DEVELOPMENT SCENARIOS AND DEVELOP PROJECT COSTS AND SCHEDULES.
5. TO RANK THE DEVELOPMENT SCENARIOS AND TEST THEM VERSUS THE STAGE I EVALUATION CRITERIA.
6. TO SELECT THE BEST SCHEME (S).
7. TO IDENTIFY ADDITIONAL WORK REQUIRED TO DEMONSTRATE COMMERCIAL VIABILITY OF NON-PROVEN TECHNOLOGY.
8. TO PRESENT RESULTS TO AUDIENCES SELECTED BY THE GOVERNMENT.

ENGINEERING MANHOURS

TASK NO.	DESCRIPTION	MANHOURS
1	LIST ALL SCHEMES FOR EVALUATION	80
2	DETERMINE SERVICE FACTORS AND PROCESS TRAINS	200
3	DEVELOP GEOLOGICAL COLUMN	520
4	DESIGN MINING CASES	3,640
5	DEVELOP MINING TECHNOLOGY SIZE vs COST FUNCTION	1,360
6	OBTAIN EXTRACTION DATA FROM LICENSORS	960
7	DEVELOP EXTRACTION UNIT PROCESS DESIGNS	2,400
8	IDENTIFY EXTRACTION 'SOFT' TECHNOLOGY	1,200
9	OBTAIN UPGRADING DATA FROM LICENSORS	1,360
10	DEVELOP UPGRADING UNIT PROCESS DESIGNS	2,880
11	SUB-OPTIMIZE UPGRADING TECHNOLOGY	2,040
12	IDENTIFY UPGRADING 'SOFT' TECHNOLOGY	1,200
13	DEVELOP UTILITIES AND OFFPLOTS DESIGNS	1,560
14	DEVELOP OPERATING COST DATA	600
15	DEVELOP OPTIMIZED SCHEMES MAKING SIZE ADJUSTMENTS	1,920
16	DEVELOP OVERALL PROCESS DESIGN FOR OPTIMIZED CASES	2,800
17	DEVELOP ECONOMIC COMPARATORS	2,160
18	TEST SCHEMES AGAINST VIABILITY CRITERIA	1,520
19	SELECT BEST SCHEME (S)	640
20	REVIEW RESULTS WITH PAC	800
21	DOCUMENT SELECTED SCHEMES	1,920
22	PREPARE FINAL REPORT	2,160
23	PRESENT RESULTS TO SELECTED AUDIENCES	640
24	PROJECT MANAGEMENT	5,520
	LABOUR TOTAL	40,080

82-11-24

TASK SCHEDULE



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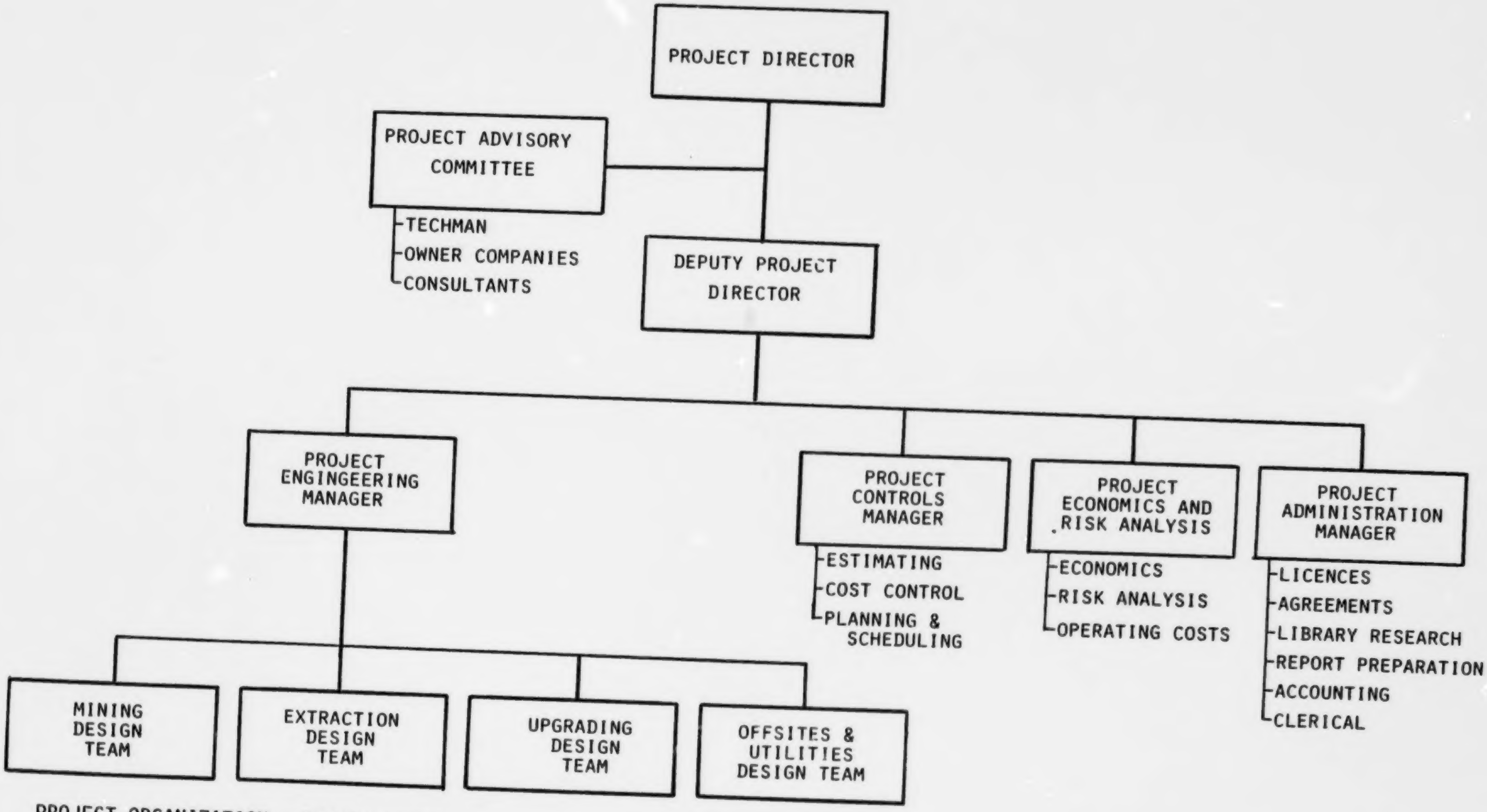
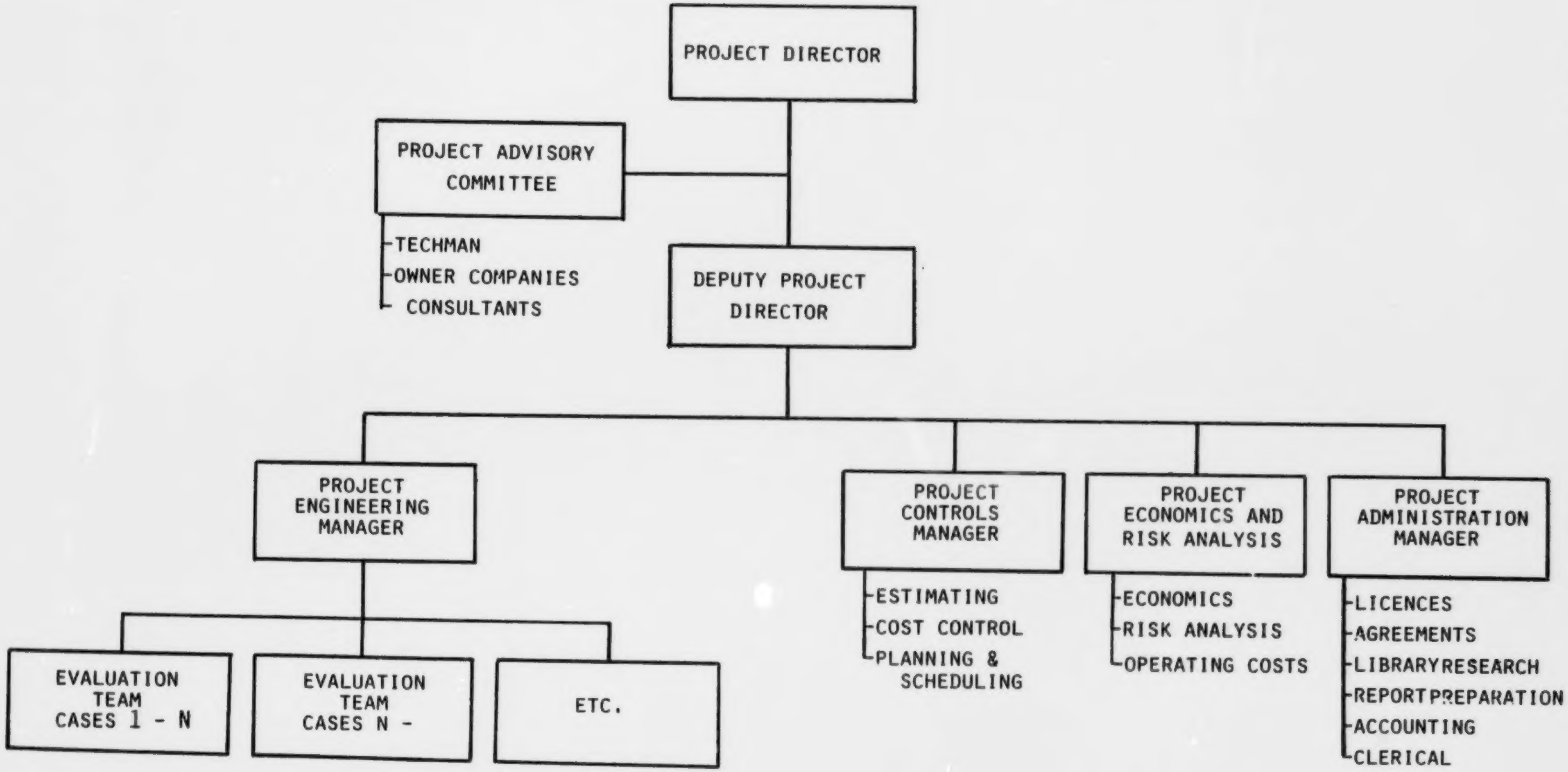

PROJECT DIRECTOR
PROJECT ADVISORY COMMITTEE
-TECHMAN
-OWNER COMPANIES
-CONSULTANTS
DEPUTY PROJECT DIRECTOR
PROJECT ENGINGEERING MANAGER
PROJECT CONTROLS MANAGER
-ESTIMATING
-COST CONTROL
-PLANNING & SCHEDULING
PROJECT ECONOMICS AND RISK ANALYSIS
-ECONOMICS
-RISK ANALYSIS
-OPERATING COSTS
PROJECT ADMINISTRATION MANAGER
-LICENCES
-AGREEMENTS
-LIBRARY RESEARCH
-REPORT PREPARATION
-ACCOUNTING
-CLERICAL
MINING DESIGN TEAM
EXTRACTION DESIGN TEAM
UPGRADING DESIGN TEAM
OFFSITES & UTILITIES DESIGN TEAM

PROJECT ORGANIZATION - DESIGN PHASE
(TASKS 1 - 13)

82-11-23


PROJECT DIRECTOR
PROJECT ADVISORY COMMITTEE
TECHMAN
OWNER COMPANIES
CONSULTANTS
DEPUTY PROJECT DIRECTOR
PROJECT ENGINEERING MANAGER
EVALUATION TEAM CASES 1 - N
EVALUATION TEAM CASES N -
ETC.
PROJECT CONTROLS MANAGER
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PROJECT ADMINISTRATION MANAGER
LICENCES
AGREEMENTS
LIBRARYRESEARCH
REPORTPREPARATION
ACCOUNTING
CLERICAL

PROJECT ORGANIZATION - OPTIMIZATION AND EVALUATION PHASE
(TASKS 14 - 22)

82-11-23

Topic 3. A presentation covering the Mobile Equipment (transport distances minimized) Mining Scheme developed by Techman.

Attendees:		
	D. E. Rose	D. W. Devenny
	A. W. Hyndman	J. W. Porteous
	F. M. Ratushny	R. M. Wrubleski
	E. Yildirim	J. E. Filby
	J. Guthrie	P.M.T. White
	A. G. Blair	J. Hrouda
	R. Evans	A. W. Wirth
	D. M. McClement	

Mr. Abbott gave a presentation of the truck and shovel mining scheme as developed in the study. Further description of this scheme is included in Appendix C of the Final Report as Case 2 and Case 3.

Unless otherwise specified, numbers quoted in the presentation are for the 100,000 BPCD plant. The following points summarize the highlights of the discussion.

1. The ore body used in sizing the equipment is the same as that used for BWE and Dragline mining schemes:

   Average mining depth = 70 m
   Overburden = 13 m
   Payzone = 45 m
   Average Grade = 11.5% bitumen
   Centre Reject = 12 m
   Waste to ore ratio = 0.55
   Ore body size = 4 km x 4 km
   Ore per year = 27 x 10^6 BCM/yr
   Waste per year = 15 x 10^6 BCM/yr

2. Modular Approach - Four 4 km² modules each mined in two triangular parts. Two modules are mined concurrently. Start with modules closest to the extraction.

3. The scheme was illustrated with four drawings displayed.

   Mining Schematic-Plan (layout of modules)
   Mining Module - Plan
   Mining Module - Perspective View
   Mining Module - Section

   Note, that reduced versions of these drawings is included in the final report, Appendix C - Case 2.

4. Mining Equipment:

	(Case 2) 100K	(Case 3) 25K
Hydraulic Shovels Demag H241	8	3

Topic 3. Continued

4. Mining Equipment: (continued)	(Case 2) 100K	Case 3) 25K
Hopper/breaker (crusher) (crusher)	3 @ 11,000 TPM	2 @ 3,000 TPM
Belt Conveyor	2 trains & 1 backup 2,000 mm	1 train & 1 backup 1,600 mm
170 Ton Trucks	31	10
85 Ton Trucks	3	2
FEL (Cat 992)	2	1
Dozers D-10	6	2
D-9L	11	3
Graders	4	2

5. Radial Mining Concept

   A pie shaped segment is mined in 12 metre high benches by hydraulic shovels in direction away from the apex. When a bench is completed, shovels return to the apex to start a lower bench. The last bench is mined with backhoe attachment on the shovel. (For more detail, see Appendix C).

6. Tarsand is loaded into 170 ton trucks, and transported to a hopper via good roads. A hopper/breaker (or crusher) is located on the pit bottom close to the apex of the module. Belt conveyor is used to transport tarsand from the hopper/breaker (crusher) to the extraction plant located at the edge of the mine.

7. Design of the hopper/breaker (crusher) needs to be developed and tested. It was noted that a conservative allowance for the hopper/breaker has been made when costing the scheme.

8. Pit opened close to the extraction utilizing hopper/breaker (crusher) conveyor system which later on functions as a backup system.

9. For 100K case, two pits operate concurrently, however equipment is sized so that one pit alone can sustain the required production.

10. Requirements for a storage system between the mine and the extraction were discussed. Sufficient volume of unmined ore is left in proximity of the backup system (close to extraction)

Topic 3. Continued

10. Continued

to be mined when main two systems are out. A possibility of stockpiling ore in proximity of the backup system (or even the main systems) was discussed.

11. When first half of the module is mined out, hopper is relocated and conveyor extended (100K case).

12. When first two modules mined out, a trunk conveyor is installed to the centre of the ore body. The remaining two modules are mined in the same manner as the first two (100K case).

13. In 25K case one hopper/breaker (crusher) and belt conveyor are permanently installed at the centre of the ore body. No relocation or extensions are required (see Appendix C, Case 3).

14. Road building material and its availability forms a very important prerequisite for the truck and shovel mining scheme. To maintain low rolling resistance for the trucks, a network of good roads has to be built. For this study it was assumed, that the road building material may be obtained either from a not too distant gravel pit or from a limestone quarry located at the pit bottom. This is a very site specific problem. After the initial roads are built out of gravel only make-up rock (or gravel) needs to be provided to cover road material lost during rehandle. Roads in the mine are rehandled from bench to bench as mining of a segment progresses downward. A discussion developed on how many times can the road material be rehandled before congested with tarsand. A concern was expressed about the possibility of limestone road material mixing with plant feed.

15. To avoid road rehandle on the waste dump (in-pit), the overburden and centre reject materials are dumped from trucks in one lift and pushed down with dozers into a stable, shallow slope. Waste dump will be about 30 metres high. A discussion developed on possible geotechnical problems of such procedures.

16. Increase in bench height will reduce road rehandle. This would be possible with mining shovel, however at the cost of losing good mining selectivity which is characteristic for a hydraulic shovel.

17. It is Techman's belief that selective mining with hydraulic shovel will result in (as compared to the dragline, bucketwheel excavation scheme):

    a) increase in plant feed grade

    b) reduction in plant feed fines

Topic 3. Continued

17. continued

- c) increase in extraction recovery
- d) decrease in tailings pond size (less fines, less sludge)

18. Rehandling of roads in the pits amounts to 2.3 x 10^6 m^3 material per year. Make-up rock from the limestone quarry at the pit bottom is estimated at 590,000 m^3/yr.

19. It is expected that no blasting will be required for these powerful hydraulic shovels. To reduce the size of lumps (frozen tarsand) dozers with rippers are assigned to the shovels during the winter months.

20. Truck and shovel mining scheme as developed in the study is believed by Techman to give low initial capital cost, low operating cost and lower overall cost per barrel of synthetic crude produced.

21. Summary of Basic Features:

- a) modular approach
- b) radial mining of each module
- c) many module combinations possible to suit ore body and/or required capacity
- d) minimize truck haulage
- e) minimize conveyor length
- f) selective mining with hydraulic shovels
- g) must have road building material

22. Several points were brought up when the Concept Development Team was canvassed by Art Wirth after the presentation. They are summarized as follows:

- a) the truck and shovel scheme has great potential
- b) more detailed, site-specific study needs to be undertaken to demonstrate feasibility of the scheme
- c) newly developed hydraulic shovels have to be demonstrated on tarsand
- d) large size, large throughput hopper/breaker (crusher) has to be demonstrated in tarsand
- e) mine roads should be constructed so that limestone dilution of plant feed is minimized during road rehandling from bench to bench.
- f) analysis should be done, to simulate mine - extraction - upgrading interaction. Feasibility study should indicate the most economical way of guaranteeing the required

Topic 3. Continued

22. continued

synthetic crude output (extra train in extraction?, overdesign the mine?, etc.)

g) the short haul radial mining scheme requires much more exhaustive planning and bore hole data than traditional tarsands mining techniques. This would be particularly critical during the early years of operation.

h) concerns which will require considerable ongoing study were identified as:

- reliability of hopper/breaker
- dewatering of pit bottom
- location, size and construction of tailings ponds - with emphasis on early years
- mobile equipment productivity
- dilution of ore with overburden and road building material
- blasting requirements if ripping does not work
- needs to quantify mine losses
- assess selection of 12 m as bench height
- use of mining (cable) shovels rather than hydraulic
- more detail on moving from one module to two or more

-END OF DAY-

Topic 4. A review of Techman's Preliminary Evaluation of Cases selected from a Matrix of Cases developed by the Concept Development Team.

The group reconvened on December 7, 1982 and the meeting was called to order by Art Wirth in the 10th floor boardroom at Techman's offices.

Attendees:
J. Guthrie
T. J. McCann
D. E. Rose
F. Callaway
J. E. Filby
F. M. Ratushny
R. M. Wrubleski
A. W. Hyndman
R. Evans
A. W. Wirth
D. M. McClement
D. S. Kim
P.M.T. White
C. J. Abbott
A. G. Blair
J. W. Porteous

The Concept Development Team was split into three groups with McCann, Guthrie and McClement as group leaders.

The task for the three groups was to evaluate the nine (9) cases in relationship to the eight (8) "wants" (excluding financial "wants" which were covered earlier in the minutes (Page 10). The modus operandi was to first rank and then analyse the "wants"; then in keeping with John Filby's remarks, address each case keeping in mind the adverse consequences.

Blair, the spokesman for Jim Guthrie's group, explained that the group spent a great deal of time on technical risk and operability and completed the two most significant "wants" which would lead them directly in the selection of cases.

These two "wants" were characterized, for purposes of the analysis, as follows:

Technical Risk:

1. Proven technology (anywhere)
2. Minimum scale up
3. Applicability to Athabasca bitumen

Operability:

1. Integration - to other units and energy systems
2. Stream factor
3. Process/operational stability
4. Systems and operational complexity
5. Flexibility and redundancy

After considerable deliberation by the groups - each explaining the rationale for their particular ratings, a concensus was established for the rating of the cases in accordance with the following table:

Cases	1	2	3	4	5	6	7	8	9
Technical Risk									
J. Guthrie	10	9	9	10	6	8	9	7	7
T. McCann	10	10	10	9.4	9.7	9.4	9.4	10	10
M. McClement	10	8	9	9	9	8	7	7	7
	10	9	9	9	8	9	9	7	7
Operability									
J. Guthrie	7	7	10	6	7	9	8	10	9
T. McCann	10	9.5	7.3	6	8.7	8.7	8.7	8.7	9.3
M. McClement	9	9	4	3	8	10	5	6	5
	9	9	7	5	8	9	7	9	9
Expandability									
TEL	1	2	7	5	10	9	5	5	3
T. McCann	3	3½	7½	7	10	10	6	6	3½
M. McClement	6	6	6	6	10	10	6	8	8
	5	5	8	8	10	10	6	7	7
Resource Utilization									
TEL	4	6	6	10	10	8	6	8	8
McCann	5	5½	5½	5	10	5½	6½	9	9
McClement	5	5	4	4	10	7	8	7	7
	5	6	6	4	10	8	6	8	8
Environmental Impact									
TEL	5	6	10	8	8	8	7	8	9
McCann	5.6	6.1	9.4	8.9	8.2	8.9	7.2	10	8.4
McClement	3	4	4	3	9	10	4	10	10
	5	6	7	6	9	9	6	10	9

Cases	1	2	3	4	5	6	7	8	9
Administration									
TEL	3	4	10	9	7	6	6	6	4
McCann	5	4	9	10	7	6	7½	6½	4
McClement	6	6	10	9	8	7	7	6	5
	5	4	10	9	7	6	7	6	4
Socio-Economic									
TEL	3	4	10	9	7	9	6	8	7
McCann	5.6	5.6	3.9	3.4	7.8	10	7.8	8.9	7.8
McClement	7	7	8	8	9	10	8	8	7
	6	6	9	9	9	10	8	8	7
Canadian Benefits									
TEL	7	7	7	7	9	10	7	7	7
McCann	6.3	7.4	6.3	5.3	9.5	10	6.8	7.4	8.4
McClement	7	8	7	7	10	10	6	8	9
	7	7	6	6	10	10	7	7	8

The ratings for all cases, both financial and non-financial were assembled, extended to include weightings, and summarized in the attached table, "Evaluation of Cases Against "Wants", Page 42.

Wirth then canvassed the group to ascertain whether or not the Conclusions as listed under Topic 5 of these minutes, were still considered to be valid.

With a change to the second conclusion to read "smaller size appears attractive "rather than "smaller size is attractive", the group took no other exceptions to these conclusions. Ralph Evans, not having participated in the team's previous meetings wished to be excepted from this agreement.

Topic 7. A review of the draft outline of the Final Stage I Report.

McClement discussed Table of Contents viewgraph, Page 43 .

EVALUATION OF CASES AGAINST 'WANTS'

WANTS	CDT WEIGHT	CASE 1		CASE 2		CASE 3		CASE 4		CASE 5		CASE 6		CASE 7		CASE 8		CASE 9	
		WT	S	WT	S	WT	S	WT		WT		WT		WT		WT		WT	
MINIMUM TECHNICAL RISK	8	10	80	9	72	9	72	9	72	8	64	9	72	9	72	7	56	7	56
MAXIMUM OPERABILITY	8	9	72	9	72	7	56	5	40	8	64	10	80	7	56	9	72	9	72
MAXIMUM EXPANDABILITY	4	5	20	5	20	8	32	8	32	10	40	10	40	6	24	7	28	7	28
OPTIMUM NATURAL RESOURCE UTILIZATION	4	5	20	6	24	6	24	4	16	10	40	8	32	6	24	8	32	8	32
MINIMUM ENVIRONMENTAL IMPACT	4	5	20	6	24	7	28	6	24	9	36	9	36	6	24	10	40	9	36
MINIMUM ADMINISTRATION	4	5	20	4	16	10	40	9	36	7	28	6	24	7	28	6	24	4	16
MINIMUM ADVERSE SOCIO-ECONOMIC IMPACT	2	6	12	6	12	9	18	9	18	9	18	10	20	8	16	8	16	7	14
MAXIMUM CANADIAN BENEFITS	2	7	14	7	14	6	12	6	12	10	20	10	20	7	14	7	14	8	16
SUB-TOTAL - NON FINANCIAL			258		254		282		250		310		324		258		282		270
SUB-TOTAL - FINANCIAL			106		145		190		122		135		66		162		55		76
TOTAL			364		399		472		372		445		390		420		337		346

ALTERNATE TARSANDS DEVELOPMENT STUDY

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(PRELIMINARY DRAFT)

ACKNOWLEDGEMENTS

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Topic 7. Continued

It was also recommended that the Executive Summary would be enhanced by the addition of graphical displays of data such as synthetic crude yield and sulphur content. To the extent possible this will be done.

Meeting Wrap-up

Art Wirth, on behalf of Techman Engineering Ltd. thanked all the team members for all their help and efforts towards a successful conclusion to the Concept Development Meetings.

He outlined the plan for the balance of Stage 1:

- draft report to C.D.T. members by Dec. 15/82
- written comments from C.D.T. members by Dec. 22/82
- reconvene for final wrap-up - tentatively set for Jan. 4/83

Depending on nature of comments, the final report may be issued to The Client prior to January 4, 1983.

Meeting adjourned.

A. W. Wirth
Vice President & Project Director
TECHMAN ENGINEERING LTD.

Volume

3

TARSANDS DEVELOPMENT STUDY

STAGE I

VOLUME III

APPENDIX C MINING SCHEMES
APPENDIX D EXTRACTION SCHEMES
APPENDIX E UPGRADING SCHEMES
APPENDIX F UTILITIES

SUBMITTED BY

TECHMAN ENGINEERING LTD.

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10 figs.

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Manager Oil Sands Technology
Alternate Fuels
Cities Service Company

Their free and full participation contributed in a major way to the success of Stage I of the study: the assumptions, conclusions and recommendations documented herein, however, are the sole responsibility of Techman Engineering Ltd. and are not represented to be a reflection of the opinions of individual members of the Concept Development Team, nor of their companies or agencies.

In describing the cases examined in this study, reference is made to certain proprietary processes in extraction and upgrading and to specific equipment items in mining. These references are illustrative and do not represent an endorsement of particular equipment items or manufacturers, nor do they reflect an opinion on the relative suitability of processes in certain applications since Stage I did not include process optimization or any detailed comparative evaluation of competing processes. Processes were selected primarily on the basis of proven technology.

APPENDIX C

MINING SCHEMES

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1.0 INTRODUCTION

Before the description and discussion of individual cases, Appendix C introduces several generalized geological columns representing typical stratigraphy in the surface mineable region of the Athabasca tarsands deposit, both east and west of the Athabasca River. Column No. 3 formed the basis for the design of the mining schemes and the calculation of the material balances in the study. Physical properties of tarsand and other materials used in the analysis are stated. These include such parameters as assumed average bitumen saturation of tarsand, unit weight of in-situ tarsand and overburden materials, swell factors, bitumen recovery curve assumed (Clark Hot Water Process) and upgrading ratio (litres of synthetic crude/litres of bitumen).

Out of the nine cases analysed in this stage of the study, the first four cases were subjected to the most detailed work. A comparison of these four cases formed the basis for the selection of the mining schemes for the remaining five cases.

The truck/shovel scheme developed in the study could be described as a system of hydraulic shovels combined with short haul trucks loading a hopper/breaker located close to the centroid of the ore body. A belt conveyor provides the link between the hopper/breaker and the extraction plant located at the edge of the mine. The scheme relies upon the availability of road building material (granular or limestone quarry), as good roads are necessary to keep trucks rolling resistance down and the travel speed up. The material is required for construction of roads in the initial years of operation. In subsequent years only make-up rock or gravel is required, as most roads are rehandled and reconstructed from bench to bench. Even though the merits of selective mining were not quantitatively assessed in Stage I of the study, it is expected that the practice of selective mining with hydraulic shovels will result in an increase in plant feed grade, reduction of fines in the feed, and consequently increase in bitumen extraction recovery and decrease in tailings ponds size (less fines, less sludge).

Two different bucketwheel/dragline mining schemes were developed, a three train concept in Case 1 - 15.9k m^3/CD (100,000 BPCD) of bitumen, and a single train concept in Case 4 - 4k m^3/CD (25,000 BPCD). The application of one bucketwheel excavator (BWE) in the upper tarsand bench and two draglines with two bucketwheel reclaimers (BWR) in the lower tarsand bench appears to be the most feasible arrangement of bucketwheels and draglines in a 15.9k m^3/CD (100,000 BPCD) of bitumen mine. The concept of a single train in Case 4 may cause concern regarding the system's reliability, since the only tarsand supplier to extraction is one bucketwheel. An extensive feed surge system has been located between the mine and the extraction plant to overcome the BWE's short term outages.

2.0 GEOLOGY

In order to provide a basis for the Concept Development Team (CDT) discussions and to define design mining quantities, generalized stratigraphic columns were compiled. These columns are intended to represent six different sets of tarsand ore and waste characteristics which could be or have been encountered in tarsand mining or exploration in the Athabasca area north of Fort McMurray, Alberta. Ore body geology has been illustrated by a one-dimensional representation of strata. At this stage of investigation, the exact location of ore bodies is not important since Stage I evaluation was undertaken on a non-site specific basis. For each of the columns, it has been assumed that sufficient in-place bitumen reserves exist in the north-south and east-west direction to support a small to medium-sized tarsand mining and extraction facility for at least 25 years. It has been further assumed that plant feed grade tarsand could be recovered by surface mining methods under present-day economics and existing technology.

In general, the six columns represent the nature of occurrence of the following materials:

- Holocene Materials
  - muskeg
  - organic soils

- Pleistocene Materials
  - aeolian dune sands
  - glaciolacustrine clays and silts
  - glaciofluvial sands and gravels
  - glacial tills
  - till composed of eroded bituminous debris

- Clearwater Formation
  - marine clays and silts
  - glauconitic sands of the Wabiskaw Member (bitumen bearing)

- McMurray Formation
  - sheet sands, with alternating ore and waste layers
  - thick, well-saturated tarsand which forms the economic zones (average grade assumed to be 11.5 percent bitumen by weight, wet)
  - indurated siltstones in the upper 15 m
  - lean tarsand or barren clays described as top, centre or bottom reject
  - basal clay and basal sand
  - carbonaceous clay and coal
  - water sand (containing high pressure, saline water)

- Waterways Formation
  - limestone basement rock

For the purposes of this study, tarsand ore body data has been represented by geologic ages and formations, average stratigraphic thicknesses, layer nomenclature, general comments and some engineering properties. A variety of mining methods and concepts are applicable to these geological scenarios, however, the mining thickness and depth parameters are summarized in Table 2.0-1.

Column No. 1 (Figure 2.0-1)

- significant thickness of Clearwater Formation clays - this material requires special treatment during overburden removal. Geotechnical problems have been encountered with respect to slope stability and trafficability for mobile equipment;

- indurated siltstone lenses in the upper 15 m of McMurray Formation - this is a difficult problem for bucketwheel mining and usually involves blasting in advance of excavation; and

- basal clay zones and associated watersands - these basal clays would create trafficability and bearing capacity problems for rubber tire and crawler-mounted mining equipment operated on the floor of the

Table 2.0-1

Summary of Geological Columns

Parameters	Column No. 1	Column No. 2	Column No. 3	Column No. 4	Column No. 5	Column No. 6
Average Overburden Thickness (m)	19	17	13	3	14	14
Average Mineable Tarsands Thickness (m)	34	46	45	38	54	58
Average Centre Reject Thickness (m)	6	-	12	20	42	18
Average Mining Depth (m)	59	63	70	61	110	90
Average Waste/Ore Ratio (BCM/BCM)	0.74	0.37	0.56	0.61	1.04	0.55

pit. The watersands (containing saline water) would have to be depressurized well in advance of mining.

Column No.2 (Figure 2.0-2)

- presence of the Clearwater Formation clays - similar problems would be expected as those discussed for No. 1;

- no separation of centre reject - the pay zone is considered to be a continuous sequence of economic tarsand and no attempt would be made at selective mining; and

- no basal zone - the ore body is situated on a Devonian "high", with the result that economic tarsand is continuous to the limestone basement rocks. Therefore, there are no basal aquifers which need to be dewatered.

Column No. 3 (Figure 2.0-3)

- multiple pay zones - in this case, thick payzones are separated by substantial thicknesses of centre reject. A mining scheme used would have to be capable of minimizing the dilution and mining losses associated with selective mining;

- thick watersands in the basal zone - a depressurization program would be necessary prior to any tarsand mining;

- this column formed the basis for the design of mining schemes and the calculation of material balances in this study.

Column No. 4 (Figure 2.0-4)

- no muskeg - most of the tarsand ore bodies in the Athabasca area are covered by muskeg. In this example, however, the glacial materials are shown at the surface, and this would be associated with a light tree cover;

- sheet sand zone - for this case, the upper part of the McMurray Formation is comprised of a series of alternating bands of ore grade tarsand and waste. The recovery of these thin tarsand layers may restrict the use of large scale equipment (such as bucketwheels and draglines) and would favour small, mobile and selective types of excavation equipment. There is sufficient colour contrast between the layers to allow for selective mining; and

- basal sand zone - this is a competent material which would provide good trafficability conditions for mobile equipment operated on the floor of the pit (if necessary). The basal sand and an underlying watersand are known to contain high pressure, saline water. The aquifers would have to be depressurized prior to mining.

Column No. 5 (Figure 2.0-5)

- sheet sand zone - a similar occurrence to that described for Column No. 4;

- indurated siltstone lenses - these hard lenses are usually found in the upper 15 m of the McMurray Formation and would pose a difficult problem for bucketwheel mining. The usual remedy is blasting in advance of mining;

- basal clay zone and associated watersands - these basal clays would create trafficability and bearing capacity problems for rubber tire and crawler-mounted mining equipment operated on the floor of the pit. The watersands (containing saline water) would have to be depressurized well in advance of mining; and

- deep payzone - in this example, a thick, fairly well saturated payzone is found under a massive cover of basal clay, carbonaceous clay, coal and water sand. For a mine plan, efforts would be made to maximize the tarsand resource recovery, however, mining economics would govern the recovery of this deep payzone.

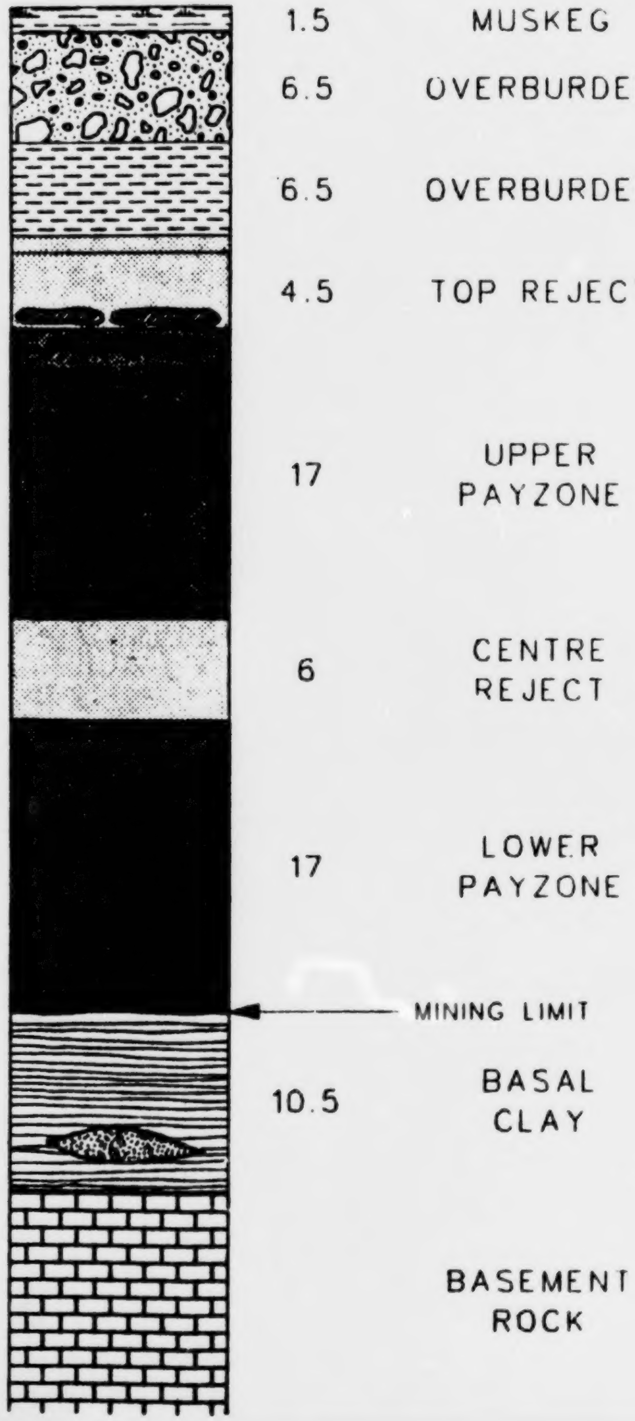
Column No. 6 (Figure 2.0-6)

- the column is similar to No. 5;
- basal clay zone considerably less in thickness than in the previous column, making recovery of the lower payzone much more feasible; and
- watersand located below the mining limit would have to be depressurized in advance of mining.

ALTERNATE TARSANDS DEVELOPMENT
GENERALIZED STRATIGRAPHIC COLUMN No.1

FIGURE 2.0 – 1

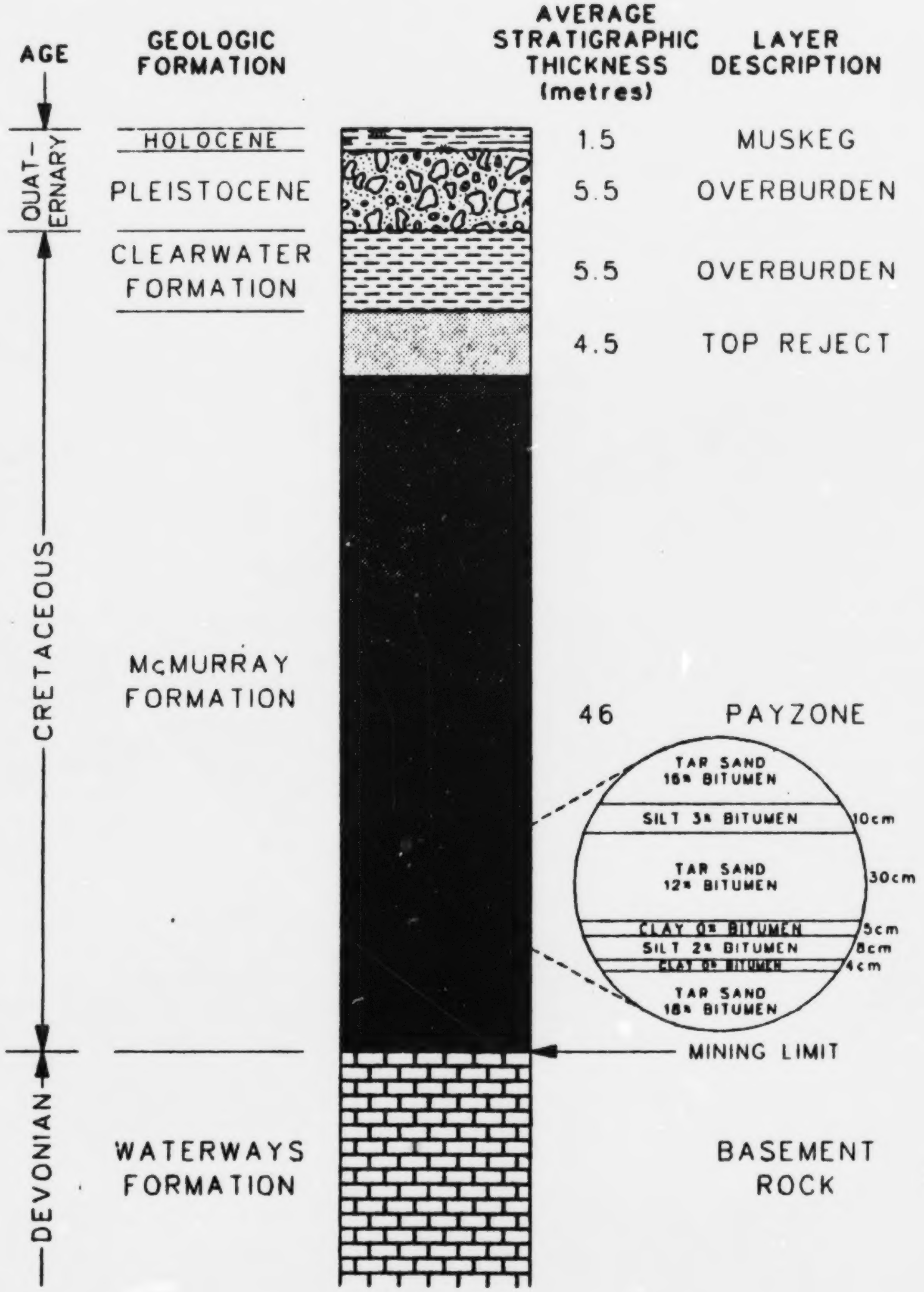
SCALE 1 : 400



AGE	GEOLOGIC FORMATION	AVERAGE STRATIGRAPHIC THICKNESS (metres)	LAYER DESCRIPTION	GENERAL COMMENTS
QUATERNARY	HOLOCENE	1.5	MUSKEG	Most of surface area covered by muskeg and organic soils. Muskeg is characterized by high water content and low bearing capacity, requires draining prior to excavation.
	PLEISTOCENE	6.5	OVERBURDEN	This overburden layer is comprised of glacial materials such as aeolian dune sands, glacio-lacustrine clays and silts, glaciofluvial sands and gravels, and glacial tills. This layer usually contains a groundwater aquifer and is a potential source of granular materials such as clean sands and gravels.
CRETACEOUS	CLEARWATER FORMATION WABISKAW MEMBER	6.5	OVERBURDEN	The Clearwater Formation is a sequence of clays and silts deposited in a quiet marine environment. Adverse geotechnical conditions are to be expected, with problems in slope stability and trafficability. The Wabiskaw Member is a bitumen-bearing glauconitic sand at the base of the Clearwater Formation.
	McMURRAY FORMATION	4.5	TOP REJECT	Uneconomic layer of lean tarsand at the top of the McMurray Formation. This is a mixture of silts and clays, with an average bitumen content less than 3%. This material would be removed with the other overburden layers.
		17	UPPER PAYZONE	This upper payzone is mostly a thick, rich, massive and well-saturated tarsand. This layer is a complex mixture of sands, silts and clays, with bitumen impregnation controlled by porosity. The bitumen impregnation is not homogeneous, but varies in richness from 0 to 18% (average bitumen content = 12%). Tabular lenses of siltstone (up to 0.5 m thick) are found frequently in the top 15 m of the McMurray Formation.
		6	CENTRE REJECT	Uneconomic layer of lean tarsand found between two payzones. This is a mixture of silts and clays, with less than 3% grade and a high fines content. Only one centre reject band is shown here, however two or more major bands could appear in the economic tarsand zone.
		17	LOWER PAYZONE	The lower payzone is similar to the upper, except that the sand grain size is coarser and indurated siltstones are not usually found here.
		10.5	BASAL CLAY	The basal clay zone is comprised of a number of black to light grey kaolinitic clays. Water sands containing high pressure, saline water are found here. It would be expected that trafficability on the basal clays would be difficult for rubber-tire or crawler-mounted mobile equipment.
DEVONIAN	WATERWAYS FORMATION		BASEMENT ROCK	Limestone basement rock which forms a stable foundation for overlying materials.

ALTERNATE TARSANDS DEVELOPMENT
GENERALIZED STRATIGRAPHIC COLUMN No.2
FIGURE 2.0 – 2

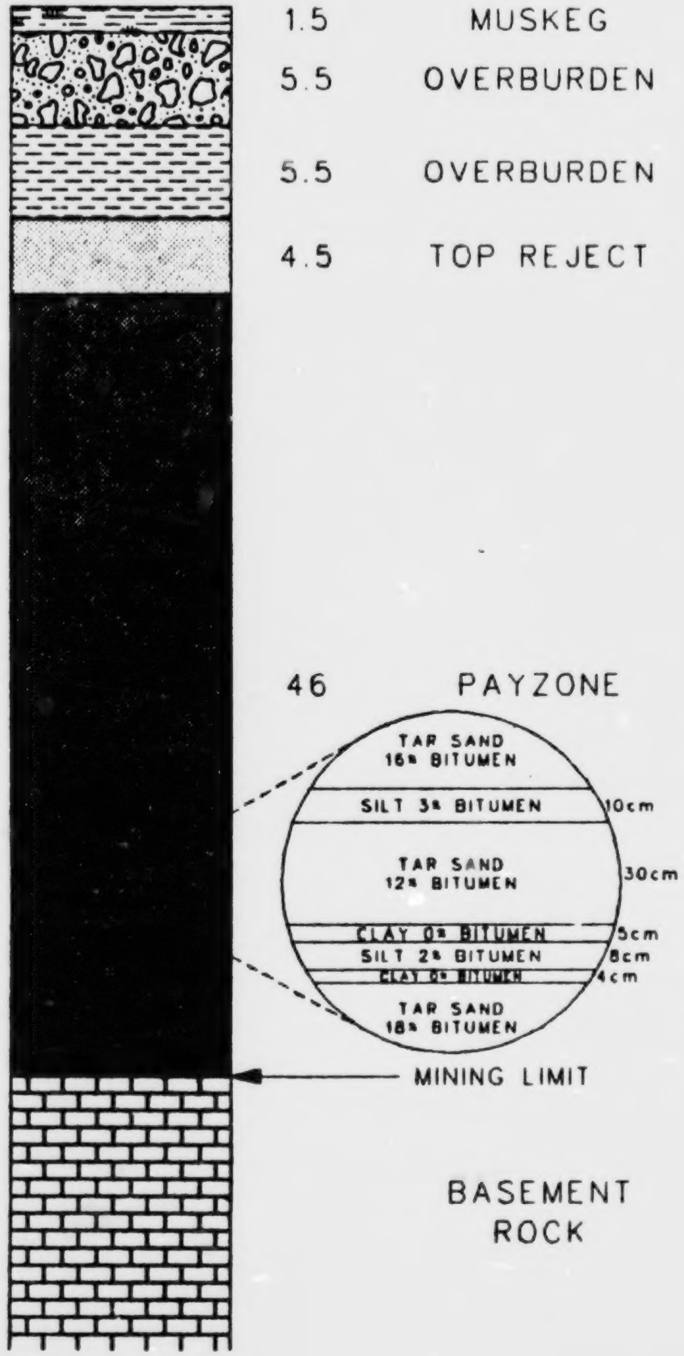
SCALE 1 : 400



AGE	GEOLOGIC FORMATION	AVERAGE STRATIGRAPHIC THICKNESS (metres)	LAYER DESCRIPTION	GENERAL COMMENTS
QUATERNARY	HOLOCENE	1.5	MUSKEG	Most of surface area covered by muskeg and organic soils. Muskeg is characterized by high water content and low bearing capacity; requires draining prior to excavation.
	PLEISTOCENE	5.5	OVERBURDEN	Glacial drift comprised of glaciolacustrine clays and silts, glaciofluvial sands and gravels, and tills. This layer contains a groundwater aquifer and is a potential source of granular materials such as clean sands and gravels.
CRETACEOUS	CLEARWATER FORMATION	5.5	OVERBURDEN	The Clearwater Formation is a sequence of clays and silts deposited in a quiet marine environment. Adverse geotechnical conditions are to be expected, with problems in slope stability and trafficability.
		4.5	TOP REJECT	Uneconomic layer of lean tarsand at the top of the McMurray Formation. This is a mixture of silts and clays, with an average bitumen content less than 3%. This material would be removed with the other overburden layers.
	McMURRAY FORMATION	46	PAYZONE	This payzone is the economic zone of the McMurray Formation. It is shown here as a complex mixture of sands, silts and clays with bitumen impregnation depending on porosity. For the most part, the tarsand is massive and well saturated, however, there are some non-specific bands of centre reject. Grain size coarsens in the downward direction and the bitumen impregnation is not homogeneous, but varies from 0 to 18% (average bitumen content = 12%). Stiff, grey plastic clay bands (2 – 5 cm thick) are prevalent at the top of this economic zone. Highwall stability problems could result if these clay bands are in an adverse orientation. No basal clay zone or watersand are to be found here, with mineable tarsand overlying the Devonian limestone rocks.
DEVONIAN	WATERWAYS FORMATION		BASEMENT ROCK	Limestone basement rock which forms a stable foundation for overlying materials.

ALTERNATE TARSANDS DEVELOPMENT
GENERALIZED STRATIGRAPHIC COLUMN No.2
FIGURE 2.0 – 2

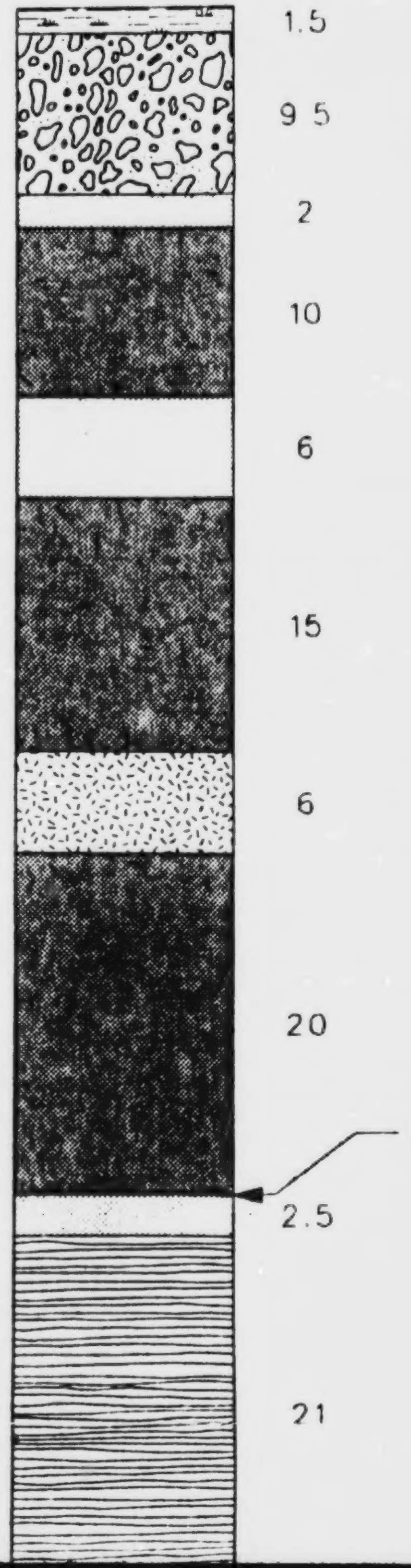
SCALE 1 : 400



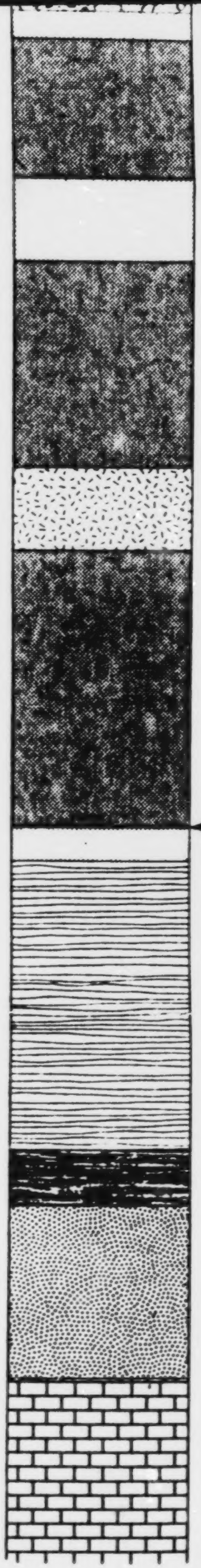
AGE	GEOLOGIC FORMATION	AVERAGE STRATIGRAPHIC THICKNESS (metres)	LAYER DESCRIPTION	GENERAL COMMENTS
QUATERNARY	HOLOCENE	1.5	MUSKEG	Most of surface area covered by muskeg and organic soils. Muskeg is characterized by high water content and low bearing capacity; requires draining prior to excavation.
	PLEISTOCENE	5.5	OVERBURDEN	Glacial drift comprised of glaciolacustrine clays and silts, glaciofluvial sands and gravels, and tills. This layer contains a groundwater aquifer and is a potential source of granular materials such as clean sands and gravels.
CRETACEOUS	CLEARWATER FORMATION	5.5	OVERBURDEN	The Clearwater Formation is a sequence of clays and silts deposited in a quiet marine environment. Adverse geotechnical conditions are to be expected, with problems in slope stability and trafficability.
	McMURRAY FORMATION	4.5	TOP REJECT	Uneconomic layer of lean tarsand at the top of the McMurray Formation. This is a mixture of silts and clays, with an average bitumen content less than 3%. This material would be removed with the other overburden layers.
		46	PAYZONE	This payzone is the economic zone of the McMurray Formation. It is shown here as a complex mixture of sands, silts and clays with bitumen impregnation depending on porosity. For the most part, the tarsand is massive and well saturated, however, there are some non-specific bands of centre reject. Grain size coarsens in the downward direction and the bitumen impregnation is not homogeneous, but varies from 0 to 18% (average bitumen content = 12%). Stiff, grey plastic clay bands (2 – 5 cm thick) are prevalent at the top of this economic zone. Highwall stability problems could result if these clay bands are in an adverse orientation. No basal clay zone or watersand are to be found here, with mineable tarsand overlying the Devonian limestone rocks.
DEVONIAN	WATERWAYS FORMATION		BASEMENT ROCK	Limestone basement rock which forms a stable foundation for overlying materials.

ALTERNATE TARSANDS DEVELOPMENT
GENERALIZED STRATIGRAPHIC COLUMN No.3
FIGURE 2.0 – 3

SCALE 1 : 400



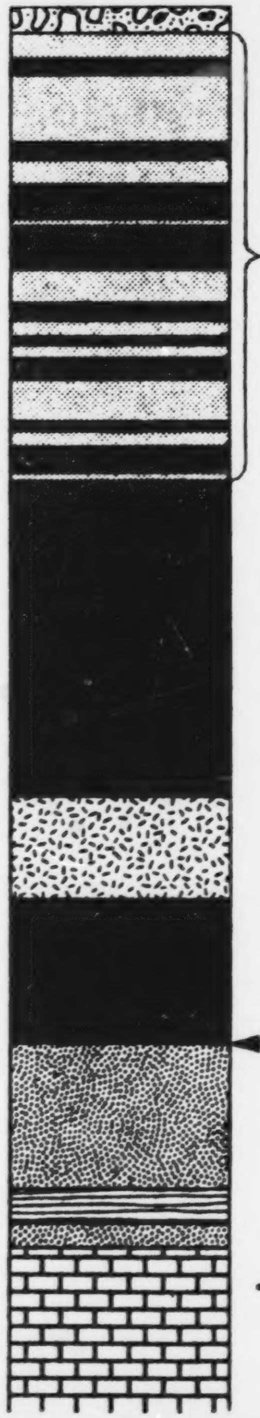
AGE	GEOLOGIC FORMATION	AVERAGE STRATIGRAPHIC THICKNESS (metres)	LAYER DESCRIPTION	GENERAL COMMENTS
QUATERNARY	HOLOCENE	1.5	MUSKEG	Most of surface area covered by muskeg and organic soils. Muskeg is characterized by high water content and low bearing capacity; requires draining prior to excavation.
	PLEISTOCENE	9.5	OVERBURDEN	This overburden layer is comprised of glacial materials such as glaciolacustrine clays and silts, glaciofluvial sands and gravels, glacial till and till of eroded bituminous debris. This layer usually contains a groundwater aquifer and is a potential source of granular materials such as clean sands and gravels.
CRETACEOUS	McMURRAY FORMATION	2	TOP REJECT	Uneconomic layer of lean tarsand at the top of the McMurray Formation. This is a mixture of mostly silts and clays, with an average bitumen content less than 3%. This material would be removed with the other overburden layers.
		10	UPPER PAYZONE	Tarsand with alternating clay and silt bands (2 – 5 cm thick), bitumen impregnation is controlled by the porosity. The average bitumen content is about 8% and the fines content is expected to be high. Adverse orientation of the clay bands would cause highwall instability problems.
		6	CENTRE REJECT	Lean tarsand similar to previously discussed top reject.
		15	MIDDLE PAYZONE	This layer is a thick, clean, well saturated tarsand. The sand grains are of a uniform, medium-grained size. The average grade is about 12%, however some very rich beds show bitumen saturations approaching 20%.
		6	CENTRE REJECT .	Thick, massive layer of grey plastic clay where any laminations have been destroyed by churning and reworking. Bitumen impregnation is totally absent in this centre reject band.
		20	LOWER PAYZONE	Coarse-grained tarsand, where the sand grains were deposited in a high energy, fluvial environment. Some rounded quartz pebbles are clearly visible and the average bitumen content is about 14%, with a range from 10 to 18%.
		2.5	BOTTOM REJECT	Lean tarsand similar to top reject.
		21	BASAL CLAY	This basal clay zone is comprised of a massive, high swelling kaolinitic clay. It would be expected that trafficability on this basal clays would be difficult for rubber-tire or crawler-mounted mobile equipment.



CRETACEOUS	McMURRAY FORMATION	2	TOP REJECT	[illegible] layer of lean tarsand at the top of the McMurray Formation. This is a mixture of mostly silts and clays, with an average bitumen content less than 3%. This material would be removed with the other overburden layers.
		10	UPPER PAYZONE	Tarsand with alternating clay and silt bands (2 - 5 cm thick), bitumen impregnation is controlled by the porosity. The average bitumen content is about 8% and the fines content is expected to be high. Adverse orientation of the clay bands would cause highwall instability problems.
		6	CENTRE REJECT	Lean tarsand similar to previously discussed top reject.
		15	MIDDLE PAYZONE	This layer is a thick, clean, well saturated tarsand. The sand grains are of a uniform, medium-grained size. The average grade is about 12%, however some very rich beds show bitumen saturations approaching 20%.
		6	CENTRE REJECT	Thick, massive layer of grey plastic clay where any laminations have been destroyed by churning and reworking. Bitumen impregnation is totally absent in this centre reject band.
		20	LOWER PAYZONE	Coarse-grained tarsand, where the sand grains were deposited in a high energy, fluvial environment. Some rounded quartz pebbles are clearly visible and the average bitumen content is about 14%, with a range from 10 to 18%.
		2.5	BOTTOM REJECT	Lean tarsand similar to top reject.
		21	BASAL CLAY	This basal clay zone is comprised of a massive, high swelling kaolinitic clay. It would be expected that trafficability on this basal clays would be difficult for rubber-tire or crawler-mounted mobile equipment.
		4	CARBONACEOUS CLAY AND COAL	This is a carbonaceous clay layer, with some accumulations of a low-ranking sub-bituminous coal. The coal seams are not thick enough to have any economic significance.
		12.5	WATER SAND	Thick sand beds containing saline water under high pressure. The water sands are found characteristically in "lows" in the Devonian paleotopography and an aquifer depressurization program would have to be undertaken before any tarsand mining. Substantial thicknesses of bitumen-bearing sand are sometimes found in this zone.
DEVONIAN	WATERWAYS FORMATION		BASEMENT ROCK	Limestone basement rock which forms a stable foundation for overlying materials.

ALTERNATE TARSANDS DEVELOPMENT
GENERALIZED STRATIGRAPHIC COLUMN No.4
FIGURE 2.0 – 4

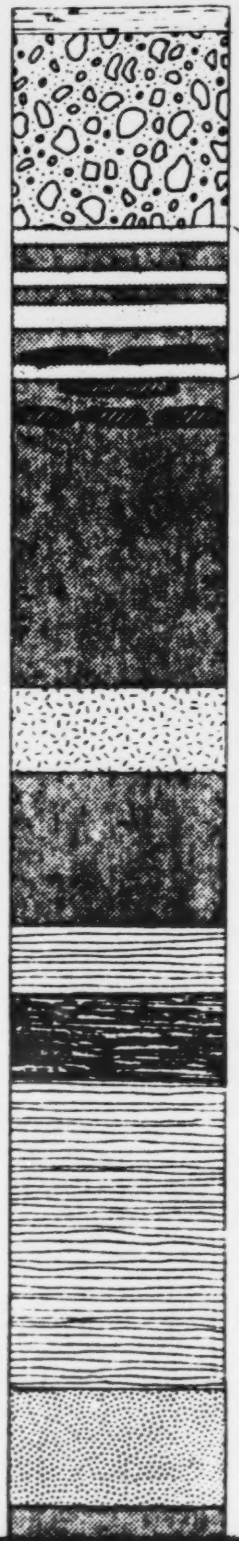
SCALE 1 : 400



AGE	GEOLOGIC FORMATION	AVERAGE STRATIGRAPHIC THICKNESS (metres)	LAYER DESCRIPTION	GENERAL COMMENTS
QUATERNARY	HOLOCENE and PLEISTOCENE	1.5	OVERBURDEN	This overburden layer is comprised of glacial materials such as glaciolacustrine clays and silts, glaciofluvial sands and gravels, and glacial till. Parts of the associated orebody may also be covered by muskeg, but this is not shown in this example. The groundwater aquifer is found at the base of this layer and is a potential source of granular materials such as clean sands and gravels.
CRETACEOUS	McMURRAY FORMATION	26.5	SHEET SAND ZONE	Alternating layers of ore grade tarsand and waste. The ore grade bands are composed of rich, well saturated tarsand with bitumen contents ranging between 12 and 16%. The waste bands are lean, uneconomic tarsand with grades less than 3%. Bitumen impregnation is controlled by porosity and there is sufficient colour contrast between layers to allow for selective mining.
		18.5	UPPER PAYZONE	Tarsand with minor clay and silt bands (2 – 5 cm thick). This layer is a rich, well saturated tarsand where the sand grains are uniform and medium size (bitumen content = 12%).
		6	CENTRE REJECT	Thick, massive layer of grey plastic clay where any laminations have been destroyed by churning and reworking. Bitumen impregnation is totally absent from this layer.
		8.5	LOWER PAYZONE	Lower payzone materials are similar to the upper, except that the sand grains are coarser and the bitumen saturation averages 14%.
			MINING LIMIT	
		8.5	BASAL SAND	Clean, coarse grained sand at the base of the economic tarsand zone. This basal sand is known to contain substantial quantities of saline water under high pressure. A depressurization program would have to be undertaken prior to mining.
		2	CLAY	Massive, high swelling, kaolinitic clay.
		1.5	WATER SAND	Watersand similar to basal sand.
DEVONIAN	WATERWAYS FORMATION	73	BASEMENT ROCK	Limestone basement rock which forms a stable foundation for overlying materials

ALTERNATE TARSANDS DEVELOPMENT
GENERALIZED STRATIGRAPHIC COLUMN No.5
FIGURE 2.0 – 5

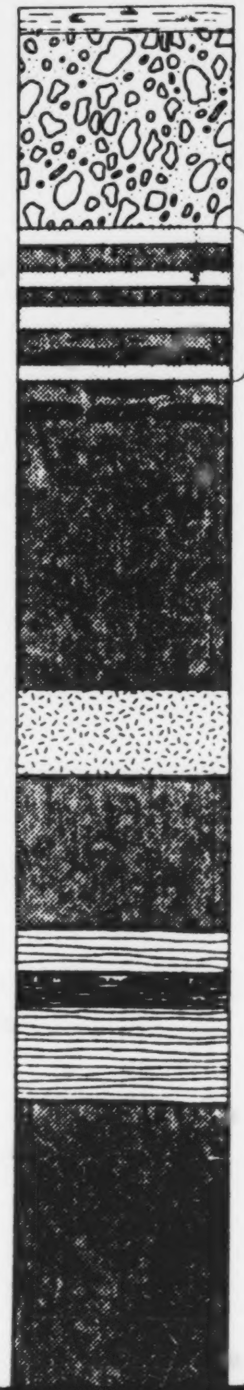
SCALE 1 : 400



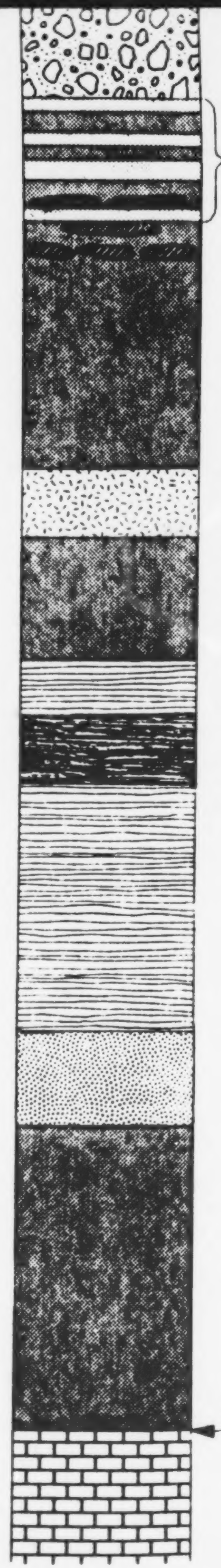
AGE	GEOLOGIC FORMATION	AVERAGE STRATIGRAPHIC THICKNESS (metres)	LAYER DESCRIPTION	GENERAL COMMENTS
QUATERNARY	HOLOCENE	1.5	MUSKEG	Most of the surface area is covered by muskeg and organic soils. Muskeg is characterized by high water content and low bearing capacity, requires drainage prior to excavation.
	PLEISTOCENE	11.5	OVERBURDEN	This overburden layer is comprised of glacial materials such as aeolian dune sands, glaciolacustrine clays and silts, glaciofluvial sands and gravels, and glacial till. This layer usually contains a groundwater aquifer and is a potential source of granular materials such as clean sands and gravels.
CRETACEOUS	McMURRAY FORMATION	9	SHEET SAND ZONE	Alternating layers of ore grade tarsand and waste. The ore grade bands are composed of rich, well saturated tarsand with bitumen contents ranging between 12 and 16%. The waste bands are lean, uneconomic tarsand with grades less than 3%. Bitumen impregnation is controlled by porosity and there is sufficient colour contrast between layers to allow for selective mining.
		18	UPPER PAYZONE	This upper payzone is mostly a thick, massive and well-saturated tarsand. This layer is a complex mixture of sands, silts and clays, with bitumen impregnation controlled by porosity. The bitumen impregnation is not homogeneous, but varies in richness from 0 to 18% (average bitumen content = 12%). Tabular lenses of indurated siltstone (up to 0.5 m thick) are found frequently in the top 15 m of the McMurray Formation.
		5	CENTRE REJECT	Thick, massive layer of grey plastic clay where any laminations have been destroyed by churning and reworking. Bitumen impregnation is totally absent in this centre reject band.
		9	MIDDLE PAYZONE	Coarse-grained tarsand, where the sand grains were deposited in a high energy, fluvial environment. Some rounded quartz pebbles are clearly visible and the average bitumen content is about 14%, with a range from 10 to 18%.
		4	BASAL CLAY	This basal clay zone is comprised of a massive, high swelling kaolinitic clay. It would be expected that trafficability on this basal clay would be difficult for rubber-tire or crawler-mounted mobile equipment. There is no sign of bitumen impregnation.
		5	CARBONACEOUS CLAY AND COAL	This is a carbonaceous clay layer, with some accumulations of a low-rank sub-bituminous coal. The coal seams are not thick enough to have any economic significance.
		18	BASAL CLAY	This basal clay is similar to the one above.
		7	WATER SAND	Coarse-grained sand deposit with some uneconomic bitumen impregnation. This watersand is known to contain substantial quantities of saline water under high pressure. An aquifer depressurization program would have to be undertaken prior to mining.

ALTERNATE TARSANDS DEVELOPMENT
GENERALIZED STRATIGRAPHIC COLUMN No.6
FIGURE 2.0 – 6

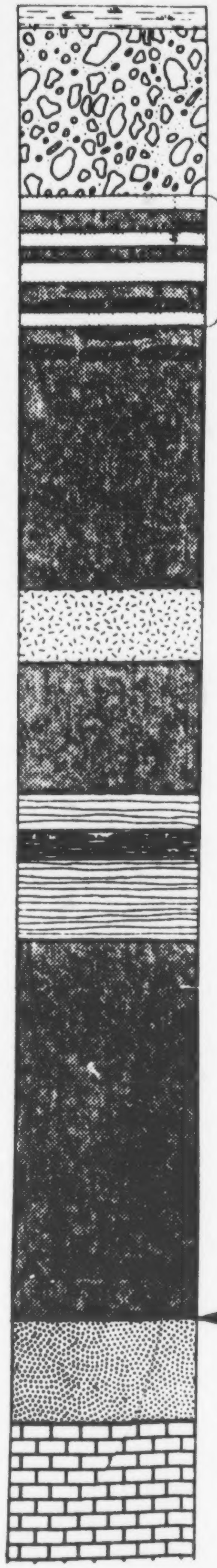
SCALE 1 : 400



AGE	GEOLOGIC FORMATION	AVERAGE STRATIGRAPHIC THICKNESS (metres)	LAYER DESCRIPTION	GENERAL COMMENTS
QUATERNARY	HOLOCENE	1.5	MUSKEG	Most of the surface area is covered by muskeg and organic soils. Muskeg is characterized by high water content and low bearing capacity, requires drainage prior to excavation
	PLEISTOCENE	11.5	OVERBURDEN	This overburden layer is comprised of glacial materials such as glaciolacustrine clays and silts, glaciofluvial sands and gravels, and glacial till. Parts of the associated orebody may also be covered by muskeg, but this is not shown in this example. The groundwater aquifer is found at the base of this layer and is a potential source of granular materials such as clean sands and gravels
CRETACEOUS	McMURRAY FORMATION	9	SHEET SAND ZONE	Alternating layers of ore grade tarsand and waste. The ore grade bands are composed of rich, well saturated tarsand with bitumen contents ranging between 12 and 16%. The waste bands are lean, uneconomic tarsand with grades less than 3%. Bitumen impregnation is controlled by porosity and there is sufficient colour contrast between layers to allow for selective mining.
		18	UPPER PAYZONE	Tarsand with minor clay and silt bands (2 – 5 cm thick). This layer is a rich, well saturated tarsand where the sand grains are uniform and medium size (bitumen content = 12%)
		5	CENTRE REJECT	Thick, massive layer of grey plastic clay where any laminations have been destroyed by churning and reworking. Bitumen impregnation is totally absent from this layer
		9	MIDDLE PAYZONE	Lower payzone materials are similar to the upper, except that the sand grains are coarser and the bitumen saturation averages 14%
		2.5	BASAL CLAY	This basal clay zone is comprised of a massive, high swelling kaolinitic clay. It would be expected that trafficability on this basal clay would be difficult for rubber-tire or crawler-mounted mobile equipment. There is no sign of bitumen impregnation.
		2	CARBONACEOUS CLAY AND COAL	This is a carbonaceous clay layer, with some accumulations of a low-rank sub-bituminous coal. The coal seams are not thick enough to have any economic significanc.
		5.5	BASAL CLAY	This basal clay is similar to the one above
		26	LOWER PAYZONE	This lower payzone is located in sand deposits found primarily in "lows" in the Devonian paleotopography. Geophysical logs indicate the bitumen content to be about 10% and this tarsand is sufficiently thick to be considered as mineable



QUAT	PLEISTOCENE	15	OVERBURDEN	The overburden layer is comprised of glacial materials such as aeolian dune sands, glacio-lacustrine clays and silts, glaciofluvial sands and gravels, and glacial till. This layer usually contains a groundwater aquifer and is a potential source of granular materials such as clean sands and gravels
CRETACEOUS	McMURRAY FORMATION	9	SHEET SAND ZONE	Alternating layers of ore grade tarsand and waste. The ore grade bands are composed of rich, well saturated tarsand with bitumen contents ranging between 12 and 16%. The waste bands are lean, uneconomic tarsand with grades less than 3%. Bitumen impregnation is controlled by porosity and there is sufficient colour contrast between layers to allow for selective mining
		18	UPPER PAYZONE	This upper payzone is mostly a thick, massive and well-saturated tarsand. This layer is a complex mixture of sands, silts and clays, with bitumen impregnation controlled by porosity. The bitumen impregnation is not homogeneous, but varies in richness from 0 to 18% (average bitumen content = 12%). Tabular lenses of indurated siltstone (up to 0.5 m thick) are found frequently in the top 15 m of the McMurray Formation
		5	CENTRE REJECT	Thick, massive layer of grey plastic clay where any laminations have been destroyed by churning and reworking. Bitumen impregnation is totally absent in this centre reject band
		9	MIDDLE PAYZONE	Coarse-grained tarsand, where the sand grains were deposited in a high energy, fluvial environment. Some rounded quartz pebbles are clearly visible and the average bitumen content is about 14%, with a range from 10 to 18%
		4	BASAL CLAY	This basal clay zone is comprised of a massive, high swelling kaolinitic clay. It would be expected that trafficability on this basal clay would be difficult for rubber-tire or crawler-mounted mobile equipment. There is no sign of bitumen impregnation
		5	CARBONACEOUS CLAY AND COAL	This is a carbonaceous clay layer, with some accumulations of a low-rank sub-bituminous coal. The coal seams are not thick enough to have any economic significance
		18	BASAL CLAY	This basal clay is similar to the one above
		7	WATER SAND	Coarse grained sand deposit with some uneconomic bitumen impregnation. This watersand is known to contain substantial quantities of saline water under high pressure. An aquifer depressurization program would have to be undertaken prior to mining
		22	LOWER PAYZONE	This lower payzone is located in sand deposits found primarily in "lows" in the Devonian paleotopography. Geophysical logs indicate the bitumen content to be about 10% and this tarsand is sufficiently thick to be considered as mineable
		110	MINING LIMIT	
DEVONIAN	WATERWAYS FORMATION		BASEMENT ROCK	Limestone basement rock which forms a stable foundation for overlying materials



AGE	FORMATION	THICKNESS (metres)	DESCRIPTION	GENERAL COMMENTS
QUATERNARY	HOLOCENE	1.5	MUSKEG	Most of the surface area is covered by muskeg and organic soils. Muskeg is characterized by high water content and low bearing capacity, requires drainage prior to excavation
	PLEISTOCENE	11.5	OVERBURDEN	This overburden layer is comprised of glacial materials such as glaciolacustrine clays and silts, glaciofluvial sands and gravels, and glacial till. Parts of the associated orebody may also be covered by muskeg, but this is not shown in this example. The groundwater aquifer is found at the base of this layer and is a potential source of granular materials such as clean sands and gravels
CRETACEOUS	McMURRAY FORMATION	9	SHEET SAND ZONE	Alternating layers of ore grade tarsand and waste. The ore grade bands are composed of rich, well saturated tarsand with bitumen contents ranging between 12 and 16%. The waste bands are lean, uneconomic tarsand with grades less than 3%. Bitumen impregnation is controlled by porosity and there is sufficient colour contrast between layers to allow for selective mining
		18	UPPER PAYZONE	Tarsand with minor clay and silt bands (2 – 5 cm thick). This layer is a rich, well saturated tarsand where the sand grains are uniform and medium size (bitumen content = 12%)
		5	CENTRE REJECT	Thick, massive layer of grey plastic clay where any laminations have been destroyed by churning and reworking. Bitumen impregnation is totally absent from this layer
		9	MIDDLE PAYZONE	Lower payzone materials are similar to the upper, except that the sand grains are coarser and the bitumen saturation averages 14%
		2.5	BASAL CLAY	This basal clay zone is comprised of a massive, high swelling kaolinitic clay. It would be expected that trafficability on this basal clay would be difficult for rubber tire or crawler-mounted mobile equipment. There is no sign of bitumen impregnation
		2	CARBONACEOUS CLAY AND COAL	This is a carbonaceous clay layer, with some accumulations of a low-rank sub-bituminous coal. The coal seams are not thick enough to have any economic significance
		5.5	BASAL CLAY	This basal clay is similar to the one above
		26	LOWER PAYZONE	This lower payzone is located in sand deposits found primarily in "lows" in the Devonian paleotopography. Geophysical logs indicate the bitumen content to be about 10% and this tarsand is sufficiently thick to be considered as mineable
		7	WATER SAND	Coarse-grained sand deposit with some uneconomic bitumen impregnation. This watersand is known to contain substantial quantities of saline water under high pressure. An aquifer depressurization program would have to be undertaken prior to mining
		97		
DEVONIAN	WATERWAYS FORMATION		BASEMENT ROCK	Limestone basement rock which forms a stable foundation for overlying materials

3.0 PHYSICAL PROPERTIES OF MATERIALS

3.1 Tarsand

3.1.1 Definition

Four-phase hydrocarbon solid consisting of a solid phase (approximately 83.0 percent by weight, predominantly sand, some clay and silt), liquid phase (water, about 5.5 percent by weight), gaseous phase (methane, carbon dioxide, carbon monoxide, nitrogen, water vapour), and viscous hydrocarbon phase (bitumen, about 11.5 percent by weight).

Economically mineable tarsand is referred to as the "payzone".

3.1.2 Physical Properties

- in-situ density - 2.08 t/BCM
  (130 lb/cu ft, 1.76 ST/BCY)

- swell factor
  - 1.20 in equipment bucket
  - 1.35 design maximum for BWE and conveyors
  - 1.20 average for BWE and conveyors
  - 1.15 stockpile

- slope angle
  - 55° digging face
  - 45° pit wall
  - 30° stockpile

- low bearing capacity in warm weather
- poor trafficability when wet
- extremely abrasive

Typically bitumen saturation (grade) averaged over approximately a 30 cm interval of payzone:
average - 11.5 percent bitumen by weight (wet)*

maximum - 18.0 percent bitumen by weight
minimum - 6.0 percent bitumen by weight, depending on cut-off grade criteria

mineral matters - 84 percent sand by weight
11 percent silt } fines (minus 44 microns)
5 percent clay }

The relationship between fines content and bitumen saturation can be approximated by:

% Bitumen (wt.)	Fines (wt. % of solids)
4	40
8	24
11.5	16 (30% of fines are clays)
16	8

A wide sample variance exists in fines versus bitumen relationship.

* Note: 100 percent weight includes water; grade figures increase for analysis of dried out samples.

3.2 Bitumen (Athabasca)

3.2.1 Definition

Very heavy, black, viscous liquid slightly heavier than water, with an API gravity of less than 10.

3.2.2 Physical Properties

Average unit weight - 1.01 tonnes/cubic metre (63.1 lb/cu ft, 0.85 ST/CY)

An average bitumen recovery for 11.5 percent of bitumen in the extraction feed is calculated as 90 percent.

3.3 Overburden

3.3.1 Defininition

Materials overlaying economically mineable tarsand.

3.3.2 Physical Properties

- in-situ density - 2.00 tonnes/bank cubic metre (125 lb/cu ft, 1.69 ST/BCY)
- swell factor - 1.35 muskeg in dumps
  - 1.15 overburden dump
  - 1.10 compacted dyke material
  - 1.20 in equipment bucket
  - 1.35 design maximum for BWE and conveyors
  - 1.20 average for BWE and conveyors
- slope angle - 55° digging face
  - 45° pit wall
  - 25° Clearwater Formation
  - 18° waste dump
  - 30° dragline back-cast

3.3.3 Composition

- organic soils of recent age
  - muskeg

- glacial drift of Pleistocene age
  - boulder sands consisting of loose, granular, unsorted material containing varying amounts of boulders, cobbles, pebbles and sand.

  - sands consisting of fine-to medium-grained sizes, with some pebbles and cobbles, traces of small boulders, and rare medium-sized boulders.
  - boulder clay consisting of grey to brown, unsorted, dense, clay beds, commonly very sandy with small amounts of pebbles, cobbles, and very few boulders. The boulder clay is often calcareous and/or petroliferous.

- Clearwater Formation
  - grey to green glauconitic sands and shales.

- uneconomic oil sands
  - quartzose sands with less than 6 percent bitumen (also defined as top reject).

3.4 Reject

3.4.1 Definition

Top Reject - lean tarsand and/or clay located above the uppermost pay zone. Usually stripped with overburden.
Centre Reject - lean tarsand and/or clay of sufficient thickness* located within the payzone.
Bottom Reject - lean tarsand located below the lowermost payzone, and left unmined.

* Note: Minimum thickness of centre reject depends on mining selectivity of equipment used, for example:

mining shovel - no selectivity (full bench)
dragline - medium selectivity 3 m
bucketwheel excavator - medium selectivity 3 m
hydraulic shovel - good selectivity 1 m

3.4.2 Physical Properties

Density, swell factor and slope angle of tarsand can be applied in calculations involving reject.

4.0 MINING SCHEMES

4.1 Case 1 Mining Scheme - 15.9k m^3/CD (100,000 BPCD) Bitumen, BWE/Dragline

4.1.1 Introduction

Case 1 is considered to be the base case in the study against which the other cases are to be compared. It should be noted, however, that at 15.9k m^3/CD (100,000 BPCD) of bitumen capacity the scheme is considerably smaller than the existing Syncrude Canada Ltd. operation or what the Alsands Energy Ltd. was to be. The mining scheme developed for Case 1 is based on the utilization of a bucketwheel excavator (BWE) and draglines (DL) in a cost effective manner as applied to tarsand mining. Stratigraphic Column No. 3 was used as basis for all cases. The plant feed was assumed to average 11.5 percent bitumen by weight for all cases. Swell factors and other parameters used in sizing of the mining equipment are stated in Section 3.0 of this Appendix (Physical Properties of Materials).

4.1.2 System Outline

The scheme utilizes three prime excavators to supply tarsand to extraction - one BWE and two draglines (with two bucketwheel reclaimers (BWR). As illustrated in Figure 4.1-1, Mining Schematic - Section, the BWE excavates blasted tarsand and centre reject from the upper tarsand bench, loading it onto the face conveyor via a belt wagon. A belt wagon rather than a conveyor bridge was selected, to provide operational flexibility. Centre reject (clay and lean tarsand) is tripped off the main belt (Conveyor 1) and dumped on the ground surface near the edge of the mined out pit through the use of a stacker. Rejected material is dozed into the mined-out pit or trucked to the dump.

The upper tarsand bench, in which the BWE operates, averages 16 m in thickness. The lower tarsand bench, 41 m thick on the average is mined by two draglines, each operating on one half of the mining face, assumed to be 4,000 m long. Draglines place plant feed grade material into a windrow and backcast clay and lean tarsand into the mined-out pit. One

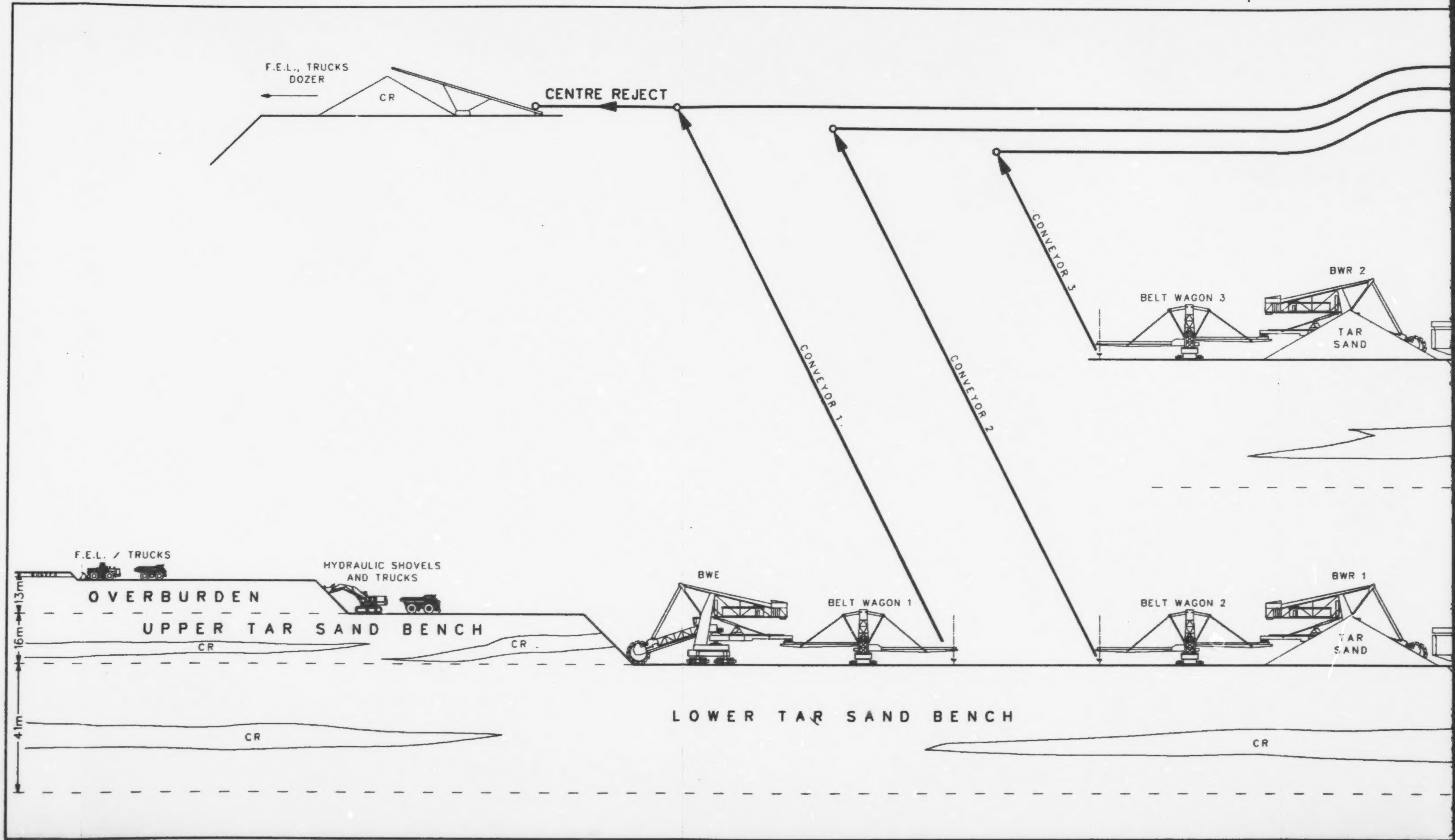
BWR is assigned to each dragline to load tarsand from the windrow onto the face conveyor. A belt wagon rather than a conveyor bridge is used with the BWR's for the same reason as stated for the BWE. Sufficient space between the upper and the lower tarsand bench must be maintained so that even in the case of a major break down with the BWE, the production from the draglines is not limited. Mining Schematic - Plan is shown on Figure 4.1-2.

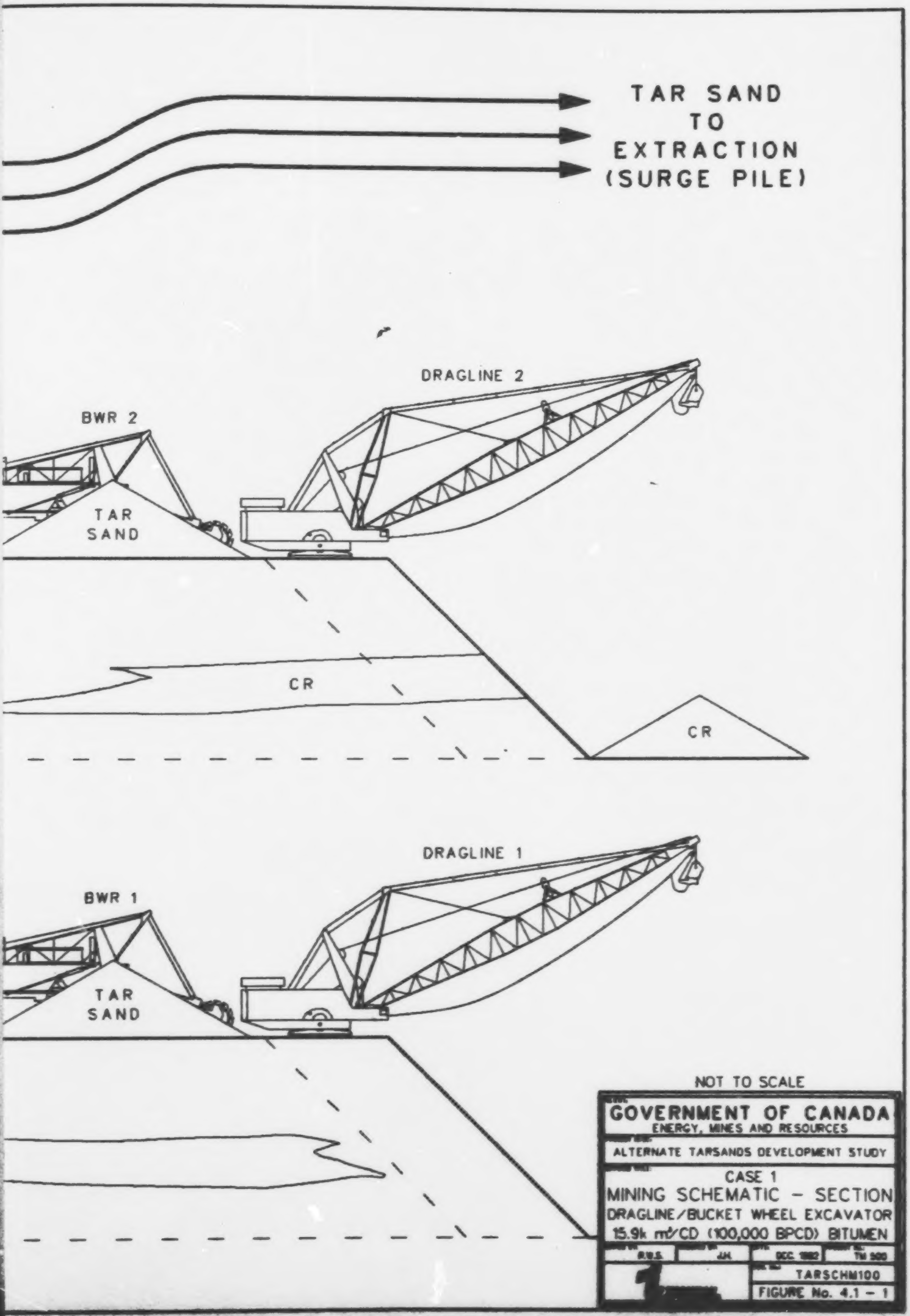
A surge pile similar to Syncrude Canada Ltd.'s is located between the mine and the Extraction Plant. Three radial stackers will be dumping into a live portion of the pile most of the time, providing approximately two hour surge capacity, while the dead portion of the pile should contain more than one day of Extraction Plant feed requirement.

Hydraulic shovels and trucks are used to strip overburden ahead of the upper tarsands bench. A portion of overburden, muskeg and underlying soft materials, are removed ahead of the shovel bench during winter months using front-end-loaders (FEL) and trucks. Overburden materials are disposed off in an out-of-pit waste dump or, when possible, an in-pit waste dump. Due to the small size of the pit (4 km x 4 km) it was assumed to be impractical to build an in-pit tailings pond. The mined out portion of the pit is used for overburden and centre reject disposal as soon as space is available.

Tailings disposal scheme selection is a very site specific task, therefore, some significant assumptions had to be made. It was assumed, that a suitable tailings pond site is available in the proximity of the Extraction Plant, similar to Suncor Inc. An in-pit tailings pond was considered impractical due to the slow forward progress of relatively long mining faces, which makes construction of a dyke with reasonable storage capacity difficult.

Four tailings lines, 60 cm in diameter, transport tailings slurry to the tailings pond. Cyclones are used to separate sand from the stream for dyke construction. Clarified tailings water is recycled back to the extraction process via a barge floating on the tailings pond and one 60 cm pipeline.


F.E.L., TRUCKS
DOZER
CR
CENTRE REJECT
CONVEYOR 1
CONVEYOR 2
CONVEYOR 3
BELT WAGON 3
BWR 2
TAR
SAND
F.E.L. / TRUCKS
HYDRAULIC SHOVELS
AND TRUCKS
13m
OVERBURDEN
16m
UPPER TAR SAND BENCH
CR
CR
BWE
BELT WAGON 1
BELT WAGON 2
BWR 1
TAR
SAND
41m
LOWER TAR SAND BENCH
CR
CR


TAR SAND
TO
EXTRACTION
(SURGE PILE)
DRAGLINE 2
BWR 2
TAR
SAND
CR
CR
DRAGLINE 1
BWR 1
TAR
SAND

NOT TO SCALE

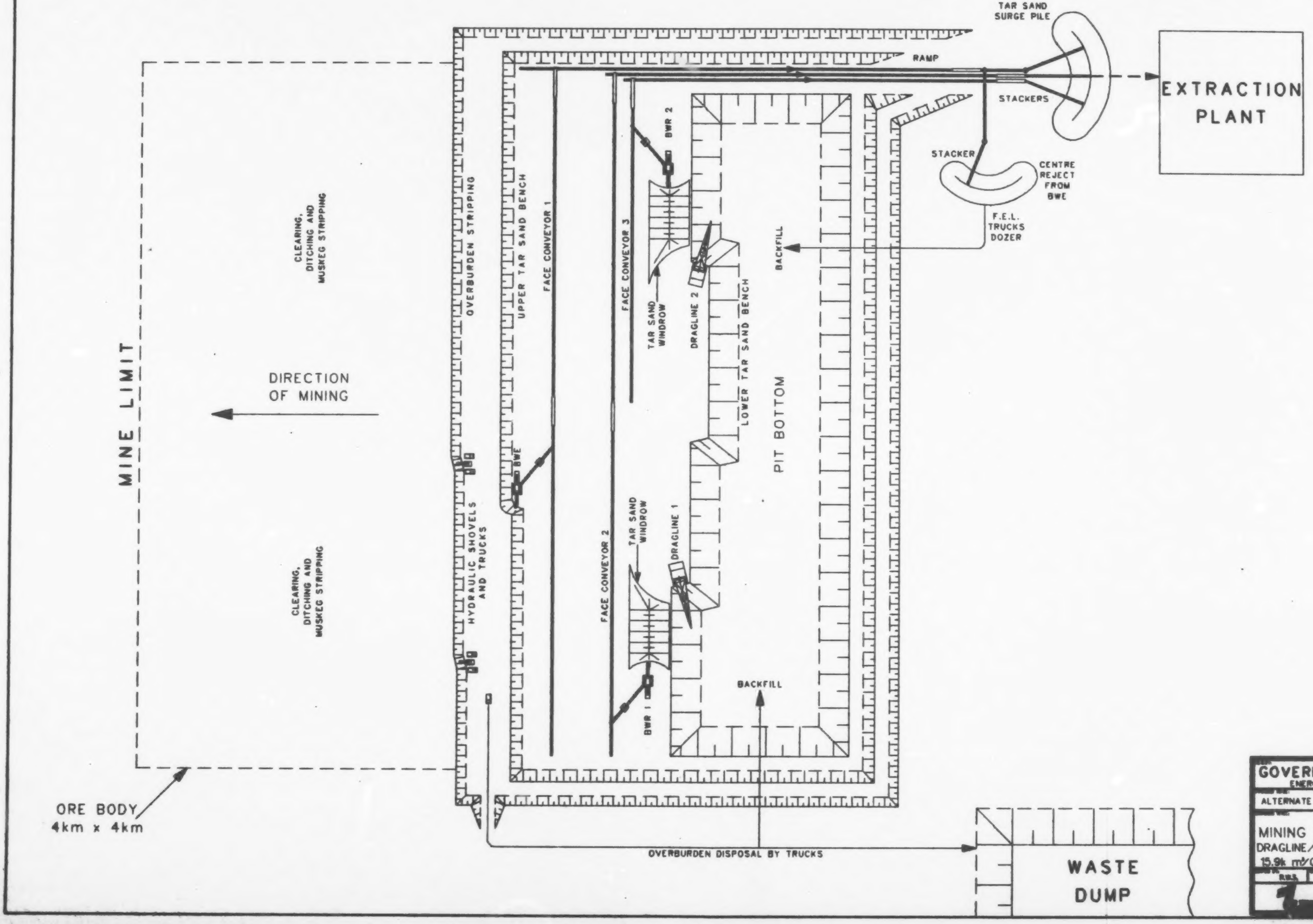
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

ALTERNATE TARSANDS DEVELOPMENT STUDY

CASE 1
MINING SCHEMATIC – SECTION
DRAGLINE/BUCKET WHEEL EXCAVATOR
15.9k m^3/CD (100,000 BPCD) BITUMEN

R.U.S.
J.H.
DEC. 1982
TM 500
TARSCHM100

FIGURE No. 4.1 – 1


TAR SAND SURGE PILE
RAMP
STACKERS
EXTRACTION PLANT
STACKER
CENTRE REJECT FROM BWE
F.E.L. TRUCKS DOZER
BACKFILL
CLEARING, DITCHING AND MUSKEG STRIPPING
OVERBURDEN STRIPPING
UPPER TAR SAND BENCH
FACE CONVEYOR 1
FACE CONVEYOR 3
BWR 2
TAR SAND WINDROW
DRAGLINE 2
LOWER TAR SAND BENCH
PIT BOTTOM
MINE LIMIT
DIRECTION OF MINING
BWE
HYDRAULIC SHOVELS AND TRUCKS
FACE CONVEYOR 2
TAR SAND WINDROW
DRAGLINE 1
CLEARING, DITCHING AND MUSKEG STRIPPING
BWR 1
BACKFILL
ORE BODY 4km x 4km
OVERBURDEN DISPOSAL BY TRUCKS
WASTE DUMP

NOT TO SCALE

GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

ALTERNATE TARSANDS DEVELOPMENT STUDY

CASE 1
MINING SCHEMATIC – PLAN
DRAGLINE/BUCKET WHEEL EXCAVATOR
15.9k m^3/CD (100,000 BPCD) BITUMEN

R.W.S. | J.H. | DEC. [illegible] | [illegible]

TARSCH100P

FIGURE No. 4.1 – 2

Equipment list:

- Draglines - two required
  BE 1570-W with 87 m boom at 38°
  bucket size = 56 m^3
  working weight = 2.87×10^6 kg

- Bucket Wheel Excavator - one required
  Bucket Wheel Reclaimer - two required
  Build reclaimers to the same specifications as the bucket wheel excavator (exchangeability)
  "C" frame, approximate weight 2000 t
  average capacity Q_{avg} = 2230 BCM/h
  effective capacity Q_{eff} = 3140 BCM/h
  theoretical capacity Q_{th} = 5500 loose m^3/h

- Belt Wagon - three required
  length = 67 m
  approximate weight = 600 t

- Belt Conveyor - three trains
  1800 mm belt width, 4.5 m/sec belt speed
  10° surcharge, 45° equal length idlers
  required maximum capacity Q_c = 6600 loose m^3/h
  conveyor length total: 4.7 km Year 1
  23.7 km Year 25

- Hydraulic Shovel - three required
  Demag H241 with 14 m^3 bucket

- Trucks
  Wabco 120 ton - 19 required
  Cat 777 (85 ton) - 14 required

- Front-End-Loaders - five required
  Cat 992

- Dozers
  Cat D-10 - 13 required
  Cat D-9L - seven required

- Graders - five required
  Cat 16 G

4.1.3 Material Balance

During an average year (steady state - full production) of operation, the mine and tailings disposal will handle the quantities of material as follows:

Muskeg stripping	1.5 x 10^6 BCM/yr
Overburden stripping	6.4 x 10^6 BCM/yr
Tarsand (plant feed)	27.2 x 10^6 BCM/yr
Centre reject	7.3 x 10^6 BCM/yr
Total pumped tailings	63.7 x 10^6 m^3/yr
sand	29.1 x 10^6 m^3/yr
sludge	10.1 x 10^6 m^3/yr
recycle water	24.5 x 10^6 m^3/yr

4.1.4 Energy Requirements

Power requirements for the mine are as follows:

Peak power -	
Mine (BWE, DL's, BWR's, Conv.)	46.0 MW
Misc. mine	5.0 MW
	51.0 MW
Average power	
Mine (BWE, DL's, BWR's, Conv.)	31.0 MW
Misc. mine	5.0 MW
	36.0 MW

The interaction of prime excavators and conveyors has been analyzed. The above indicated power for the mining equipment is based on 90 percent probability (i.e., there is 10 percent probability that the figures will be exceeded).

The mobile equipment fleet in the mine and the tailings disposal system is estimated to require 14.0 x 10^6 litres of diesel fuel per year.

4.1.5 Development of Costs

The costs for the mining and tailings systems are in 4th quarter 1982 Canadian dollars and are based on recent quotations and extrapolation of in-house costs.

The costing was done assuming the mine would be located north of Fort McMurray in the vicinity of the Suncor and Syncrude properties.

The major areas covered were:

- mine area, which included all activities up to the underground feeders to the Extraction Plant;
- tailings area, which included all activities from but not including the tailings pumps; and
- mine and tailings service complex, which included all shop's offices and laydown areas.

Fixed Capital

The items covered under fixed capital are, the granular process plant, tailings and reclaim water system, mine and tailings buildings and facilities, warehouse inventory, electrical transmission equipment, conveyors and stackers.

Mobile Capital

The items covered under mobile capital are the bucketwheel excavator and reclaimers, draglines, hydraulic shovels, rubber-tired loaders, trucks, mine auxilliary equipment, and mine maintenance mobile equipment.

Operating Costs

The operating costs include all fuel, oil, grease, maintenance parts and labour and all operating parts and labour for the equipment. The cost of electric power was not included in the mine costs. Also included in the operating costs was the mine operations, engineering, maintenance and warehouse staff, with an allowance for overhead. Operations include the costs of operating the deep well pumps and the reclamation costs.

Contract Costs

The preproduction costs include tree clearing, muskeg removal, muskeg drainage and dewatering, granular materials, road construction, camp costs, tailings pond base preparation and starter dyke construction. Also included in the preparation costs are costs for the exploration drilling and consultants required for detailed mine planning. An allowance was made for project management and engineering during the period in which major facilities and equipment are being constructed and major contracts are being administered.

During the operating years, the only items contracted were tree clearing and a limited amount of project management and engineering costs.

4.2 Case 2 Mining Scheme - 15.9k m^3/CD (100,000 BPCD) Bitumen, Truck/Shovel

4.2.1 Introduction

The mining scheme developed for Case 2 is based on the utilization of hydraulic shovels and trucks. To minimize the number of trucks required while retaining flexibility of mobile equipment mining, trunk conveyors are installed to transport tarsand from the pit to the Extraction Plant. The scheme results in very low initial capital cost, and compares favourably with the BWE/dragline scheme in operating cost as well.

What appears to be technologically the least proven item in the scheme is the large hopper/breaker (or crusher) into which trucks dump tarsand. Development and testing of a breaker or crusher capable of handling a large throughput of tarsand will have to be undertaken.

The development work on the scheme described is preliminary in nature and does not take into account site specific problems. While it is believed that the conclusions are consistent with the documented assumption, substantial work remains in Stage II to verify or modify these assumptions.

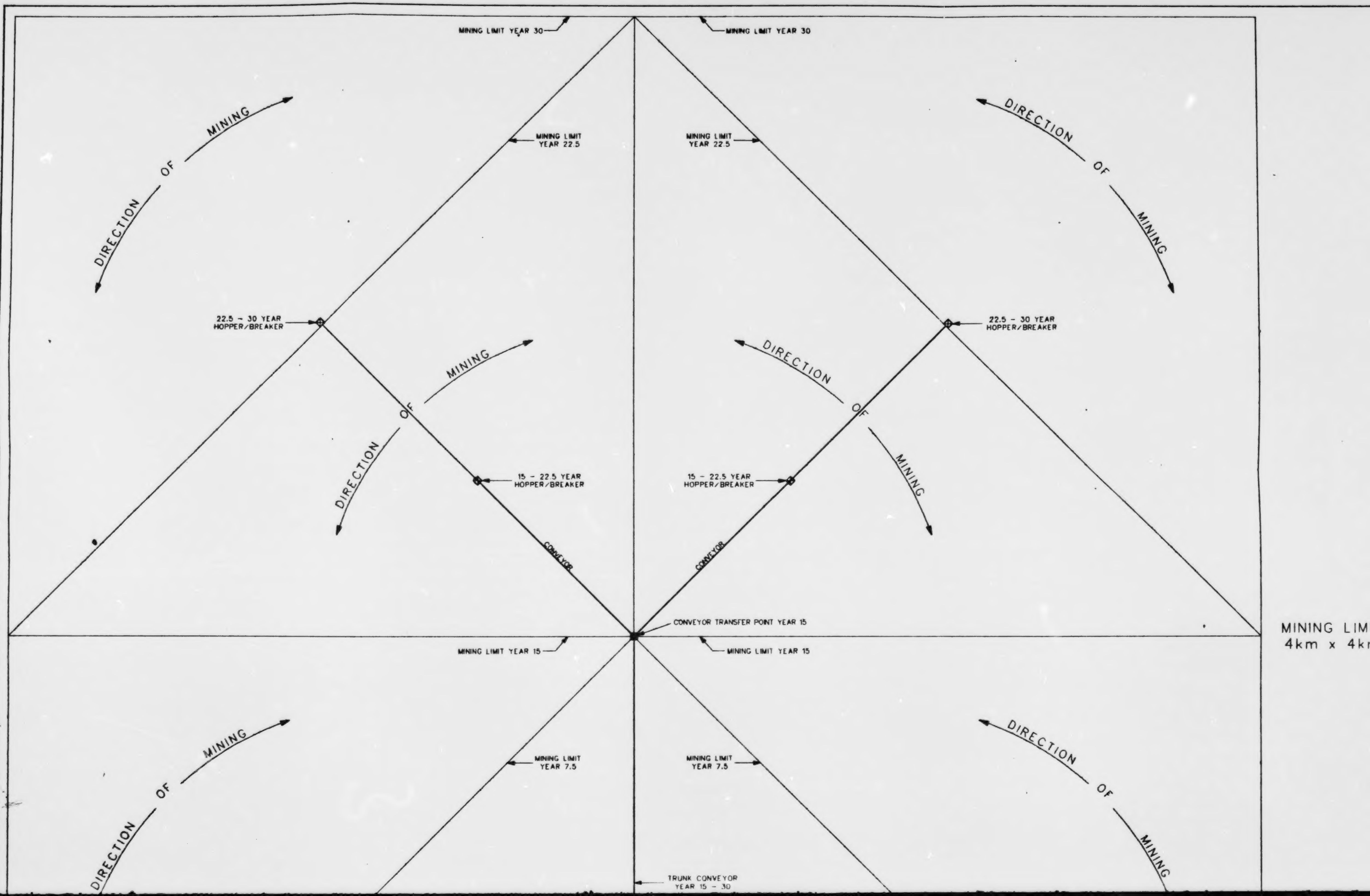
4.2.2 System Outline

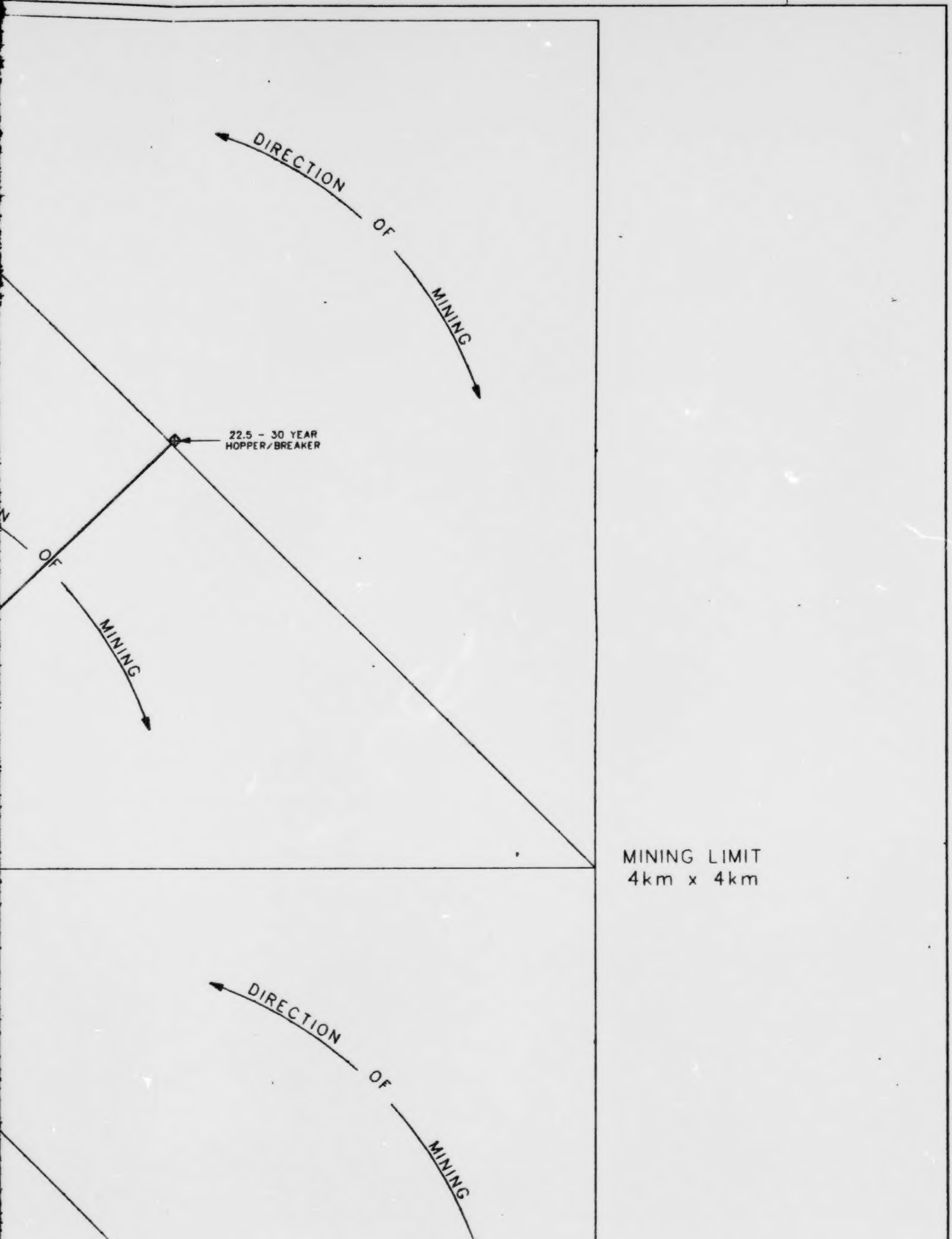
The mining scheme for Case 2 is based on a modular mine layout. A number of modular combinations is possible to suit any ore body shape, or any capacity required. For this study, the same ore body as in Case 1 was assumed to facilitate a meaningful comparison between the cases. A rectangular ore body (4 km x 4 km) is divided into modules as shown on Figure 4.2-1, Mining Schematic - Plan. Modules closest to the Extraction Plant are mined first. Hydraulic shovels such as a Demag H241 with a 14 m^3 bucket excavate all materials with the exception of muskeg, which is stripped with Front-End Loaders. Large 170 ton trucks will transport tarsand and waste (overburden and centre reject) from the shovels to the hopper/breakers (crushers) and waste dumps respectively. Belt conveyors transport tarsand from the hopper/breakers located on the pit bottom to the Extraction Plant located at the edge of the mine.

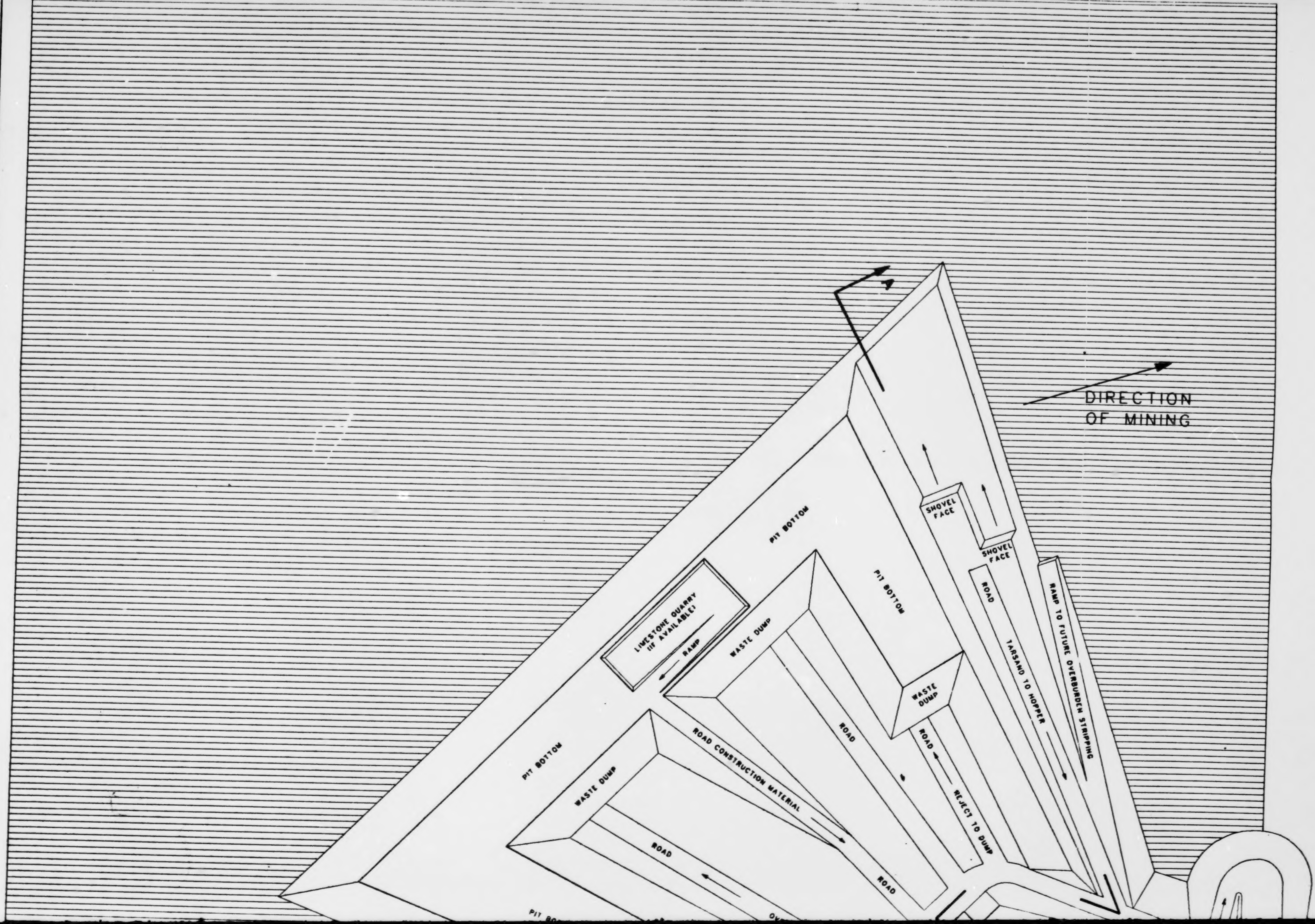
Radial mining of a module is illustrated in Figure 4.2-2, Mining Module - Plan, Figure 4.2-3 Mining Module - Perspective View, and Figure 4.2-4 Mining Module - Section A-A. These three drawings represent the left mining module in Year 6. The preproduction stripping and initial mining takes place closest to the Extraction Plant. Trucks and shovels excavate the 8 percent road down to the future location of the permanent hopper/ breaker. As this involves excavation of tarsand, the whole operation can take place in the first two years (depending on start-up schedule) of production with only one year of preproduction stripping. Tarsand is loaded into the hopper/breakers located on surface, close to the Extraction Plant. After the permanent hopper/breaker on the pit bottom is operational (complete with conveyor) a boxcut is opened radially out to the centre of the module (this is the point where the hopper/breaker will be in Years 7.5 - 15, see Figure 4.2-1). Pie-shaped segments are then mined in both directions away from the boxcut. Shovels, two on a bench, mine 12 m lifts radially away from the Extraction Plant. One pie-shaped segment is mined in this manner from top to bottom, where the last lift is excavated with one Demag fitted with the backhoe attachment. Under normal conditions, one segment is almost completely mined before overburden stripping starts on the next one. This delays overburden stripping and maximizes in-pit overburden disposal. The section (Figure 4.2-4) illustrates a segment with about 70 percent ore still to be mined. Two shovels load 170 ton trucks with plant feed (tarsand) or centre reject. The material is hauled to the hopper/ breaker or waste dump, utilizing good roads. The road network is best illustrated in the perspective view. Roads on mining benches are rehandled from bench to bench, while roads on waste dumps are permanent. This requires dozing of waste material dumped from the trucks. Approximately 30 m high waste dumps are kept stable by constant dozing at the dumping face, resulting in shallow slopes.

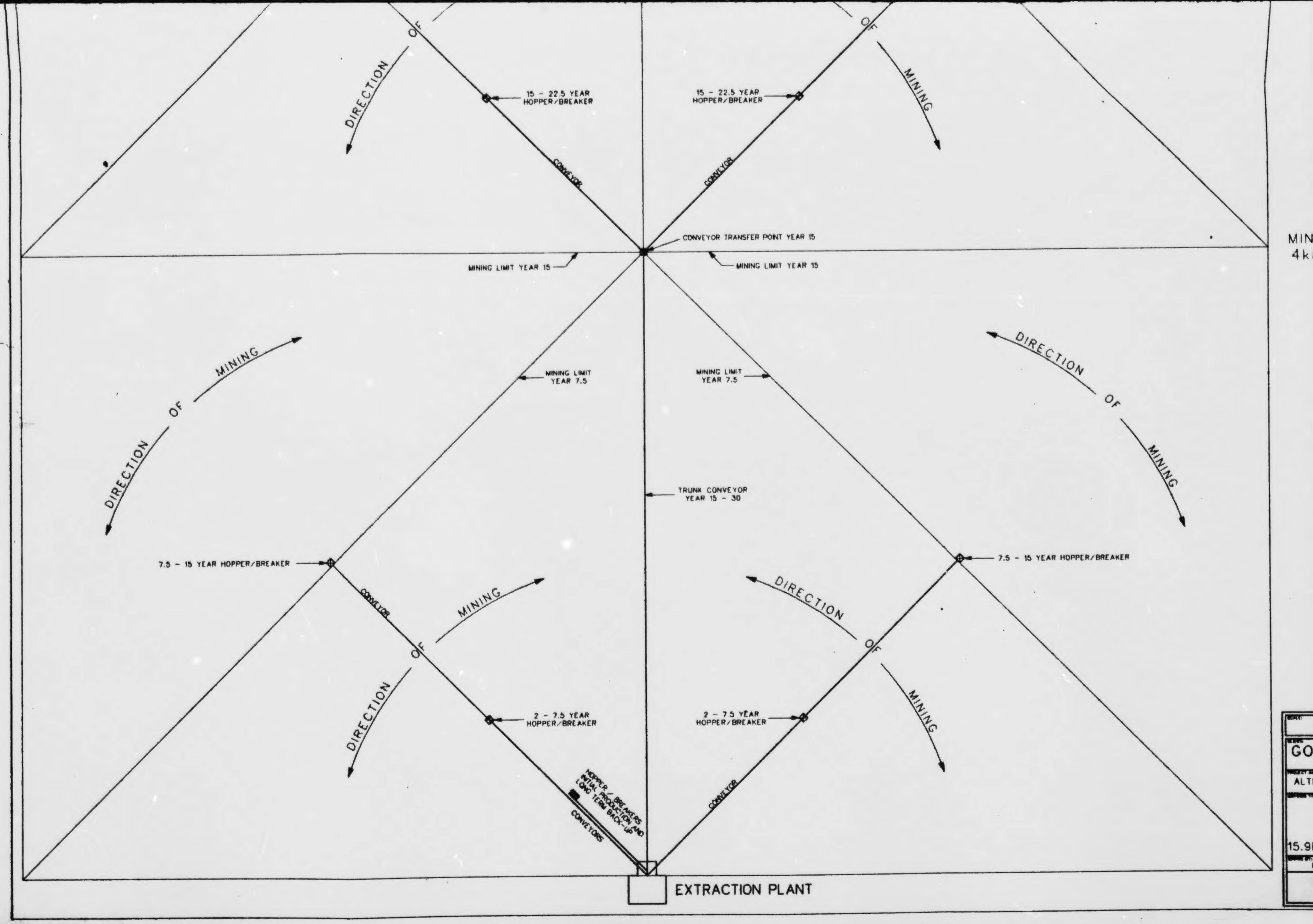
On the opposite side of the module (see the perspective view or the plan, Figures 4.2-2 and 4.2-3) a segment mining is being completed with a backhoe pass. At the same time, overburden stripping on the next segment has been commenced. Overburden is excavated with the same Demag H241 shovels, loaded into 170 ton trucks and hauled down the pit for permanent disposal in the waste dumps.

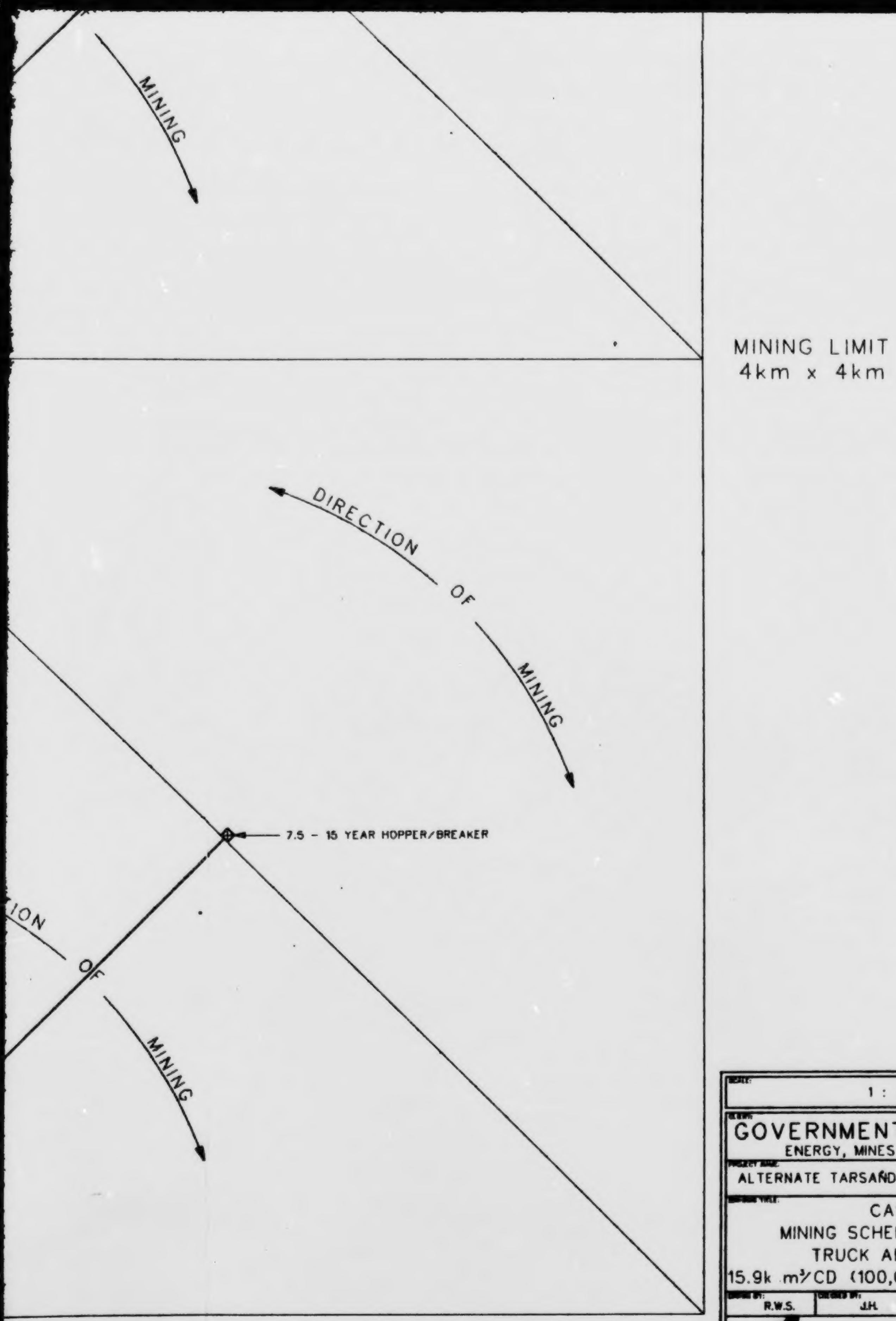
As shown on Figure 4.2-1, two modules are operational concurrently. The second module is a mirror image of that shown on Figures 4.2-2 and 4.2-3. No duplication of the back-up system is necessary.


MINING LIMIT YEAR 30
MINING LIMIT YEAR 30
DIRECTION OF MINING
DIRECTION OF MINING
MINING LIMIT YEAR 22.5
MINING LIMIT YEAR 22.5
22.5 - 30 YEAR HOPPER/BREAKER
22.5 - 30 YEAR HOPPER/BREAKER
DIRECTION OF MINING
DIRECTION OF MINING
15 - 22.5 YEAR HOPPER/BREAKER
15 - 22.5 YEAR HOPPER/BREAKER
CONVEYOR
CONVEYOR
CONVEYOR TRANSFER POINT YEAR 15
MINING LIM
4km x 4k
MINING LIMIT YEAR 15
MINING LIMIT YEAR 15
DIRECTION OF MINING
DIRECTION OF MINING
MINING LIMIT YEAR 7.5
MINING LIMIT YEAR 7.5
TRUNK CONVEYOR YEAR 15 - 30


DIRECTION OF MINING
22.5 - 30 YEAR
HOPPER/BREAKER
N
OF
MINING
MINING LIMIT
4km x 4km
DIRECTION OF MINING


A
DIRECTION OF MINING
SHOVEL FACE
SHOVEL FACE
PIT BOTTOM
PIT BOTTOM
LIMESTONE QUARRY (IF AVAILABLE)
RAMP
WASTE DUMP
WASTE DUMP
ROAD
TARSAND TO HOPPER
RAMP TO FUTURE OVERBURDEN STRIPPING
ROAD
ROAD
REJECT TO DUMP
PIT BOTTOM
WASTE DUMP
ROAD CONSTRUCTION MATERIAL
ROAD
ROAD


DIRECTION OF MINING
15 - 22.5 YEAR HOPPER/BREAKER
15 - 22.5 YEAR HOPPER/BREAKER
DIRECTION OF MINING
CONVEYOR
CONVEYOR
CONVEYOR TRANSFER POINT YEAR 15
MINING LIMIT YEAR 15
MINING LIMIT YEAR 15
MIN
4k
DIRECTION OF MINING
MINING LIMIT YEAR 7.5
MINING LIMIT YEAR 7.5
DIRECTION OF MINING
TRUNK CONVEYOR YEAR 15 - 30
7.5 - 15 YEAR HOPPER/BREAKER
7.5 - 15 YEAR HOPPER/BREAKER
CONVEYOR
DIRECTION OF MINING
DIRECTION OF MINING
2 - 7.5 YEAR HOPPER/BREAKER
2 - 7.5 YEAR HOPPER/BREAKER
HOPPER / BREAKERS INITIAL PRODUCTION AND LONG TERM BACK-UP
CONVEYORS
CONVEYOR
EXTRACTION PLANT
GO
ALT
15.9


MINING
MINING LIMIT
4km x 4km
DIRECTION OF MINING
7.5 – 15 YEAR HOPPER/BREAKER
ION OF MINING

1 : 10000

GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

ALTERNATE TARSANDS DEVELOPMENT STUDY

CASE 2
MINING SCHEMATIC – PLAN
TRUCK AND SHOVEL
15.9k m^3/CD (100,000 BPCD) BITUMEN

R.W.S.
J.H.
DEC. 1982
TM 500
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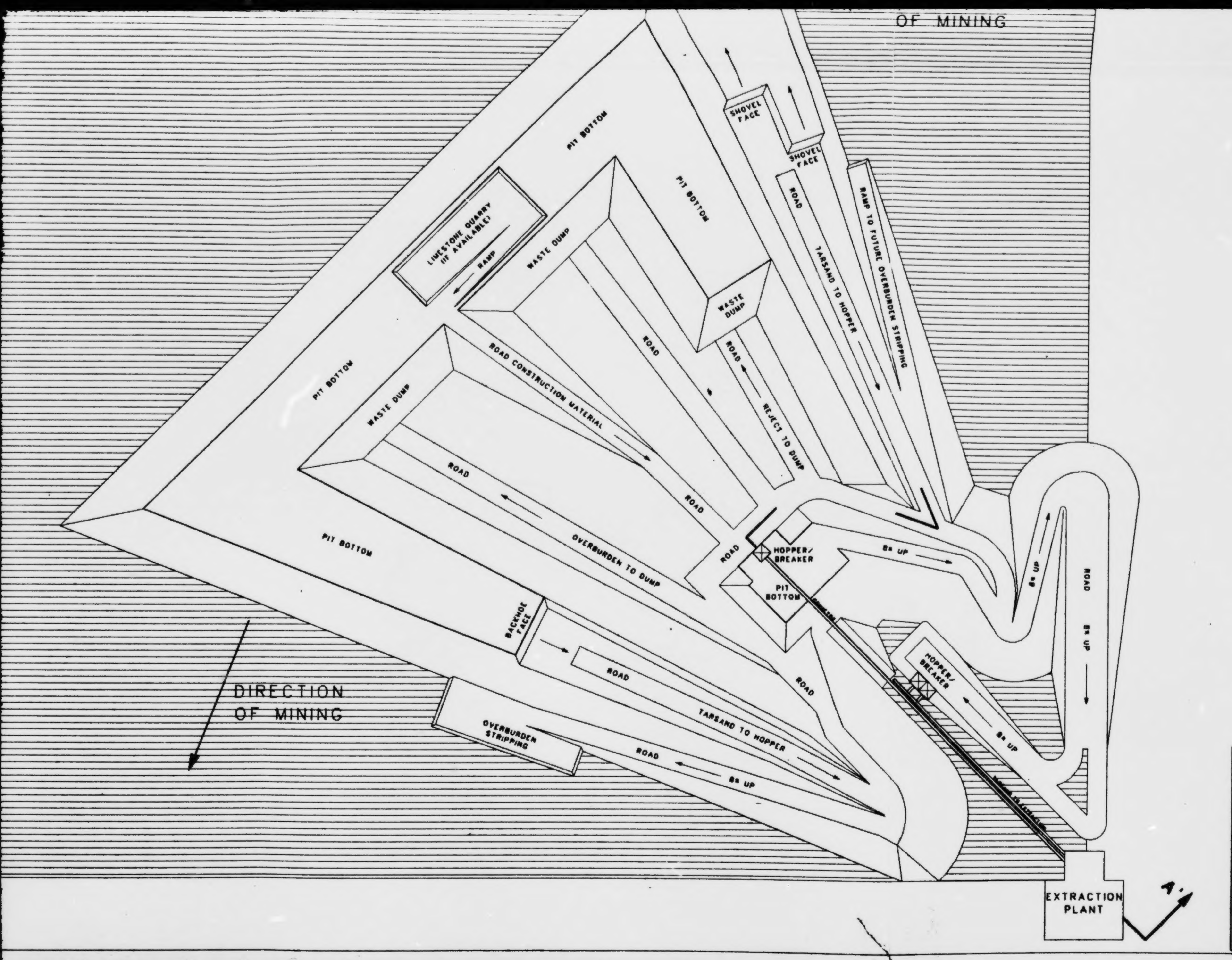
FIGURE No. 4.2 – 1


OF MINING
SHOVEL FACE
SHOVEL FACE
PIT BOTTOM
PIT BOTTOM
LIMESTONE QUARRY (IF AVAILABLE)
RAMP
WASTE DUMP
ROAD
TARSAND TO HOPPER
RAMP TO FUTURE OVERBURDEN STRIPPING
WASTE DUMP
ROAD
ROAD
REJECT TO DUMP
PIT BOTTOM
WASTE DUMP
ROAD CONSTRUCTION MATERIAL
ROAD
ROAD
PIT BOTTOM
OVERBURDEN TO DUMP
ROAD
HOPPER/ BREAKER
8% UP
8% UP
ROAD
8% UP
PIT BOTTOM
BACKHOE FACE
ROAD
ROAD
HOPPER/ BREAKER
8% UP
DIRECTION OF MINING
OVERBURDEN STRIPPING
TARSAND TO HOPPER
ROAD
8% UP
EXTRACTION PLANT
A

1 : 5000

GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

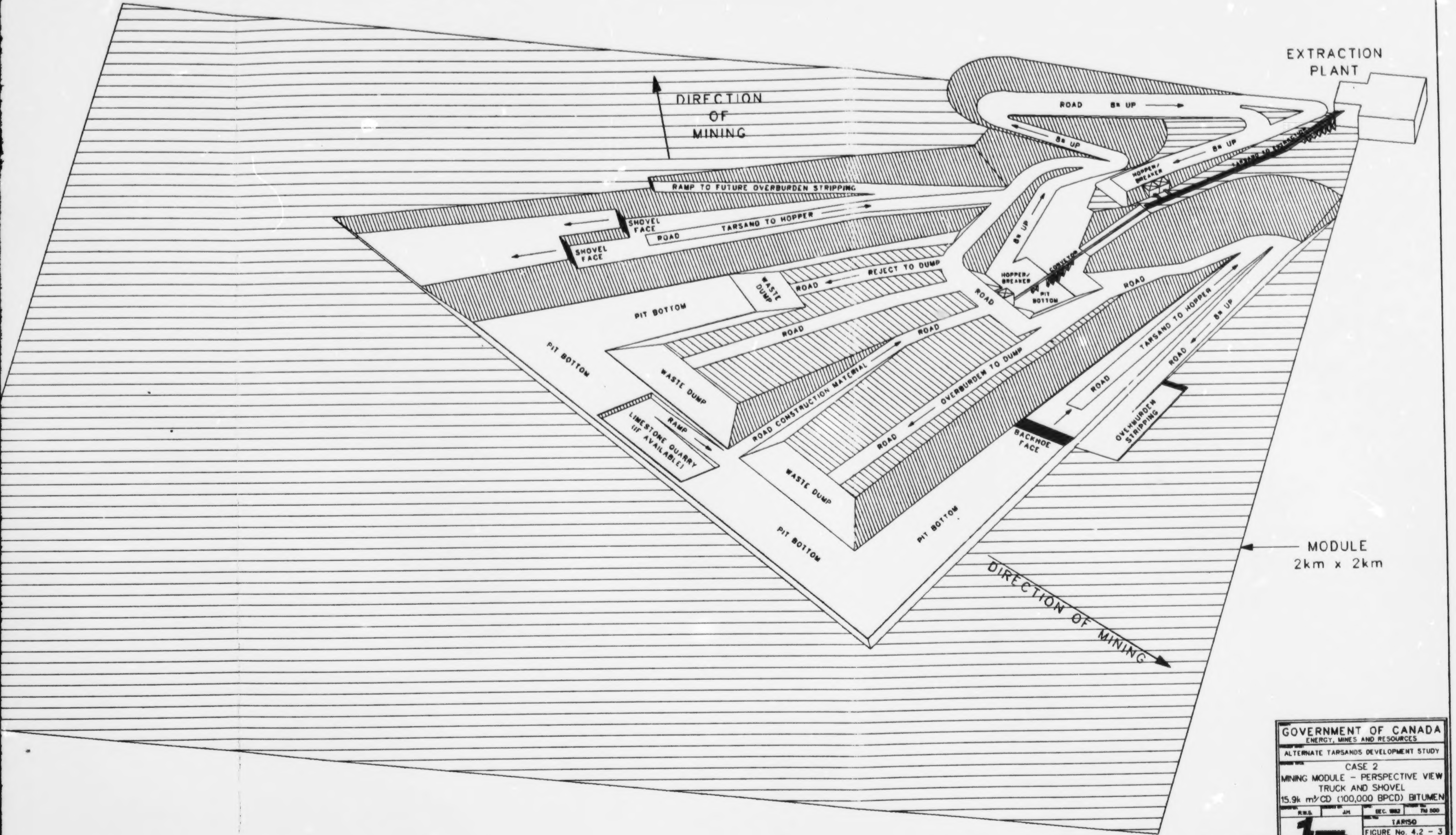
ALTERNATE TARSANDS DEVELOPMENT STUDY

CASE 2
MINING MODULE – PLAN VIEW
TRUCK AND SHOVEL
15.9k m³/CD (100,000 BPCD) BITUMEN

R.W.S.	J.H.	DEC. 1982	TM 500

TARPLAN

FIGURE No. 4.2 – 2


EXTRACTION PLANT
DIRECTION OF MINING
ROAD 8% UP
8% UP
8% UP
HOPPER/ BREAKER
TARSAND TO EXTRACTION
RAMP TO FUTURE OVERBURDEN STRIPPING
SHOVEL FACE
SHOVEL FACE
ROAD
TARSAND TO HOPPER
8% UP
REJECT TO DUMP
ROAD
WASTE DUMP
HOPPER/ BREAKER
CONVEYOR
PIT BOTTOM
ROAD
ROAD
PIT BOTTOM
ROAD
ROAD
TARSAND TO HOPPER
8% UP
PIT BOTTOM
WASTE DUMP
ROAD CONSTRUCTION MATERIAL
OVERBURDEN TO DUMP
ROAD
ROAD
LIMESTONE QUARRY (IF AVAILABLE)
RAMP
ROAD
BACKHOE FACE
OVERBURDEN STRIPPING
WASTE DUMP
PIT BOTTOM
PIT BOTTOM
MODULE 2km x 2km
DIRECTION OF MINING

GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

ALTERNATE TARSANDS DEVELOPMENT STUDY

CASE 2
MINING MODULE – PERSPECTIVE VIEW
TRUCK AND SHOVEL
15.9k m³/CD (100,000 BPCD) BITUMEN

R.W.S.
J.H.
DEC. 1982
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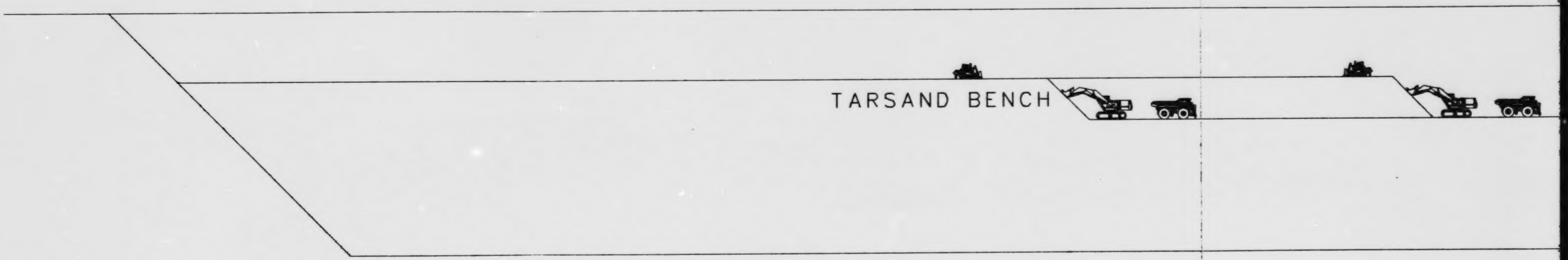
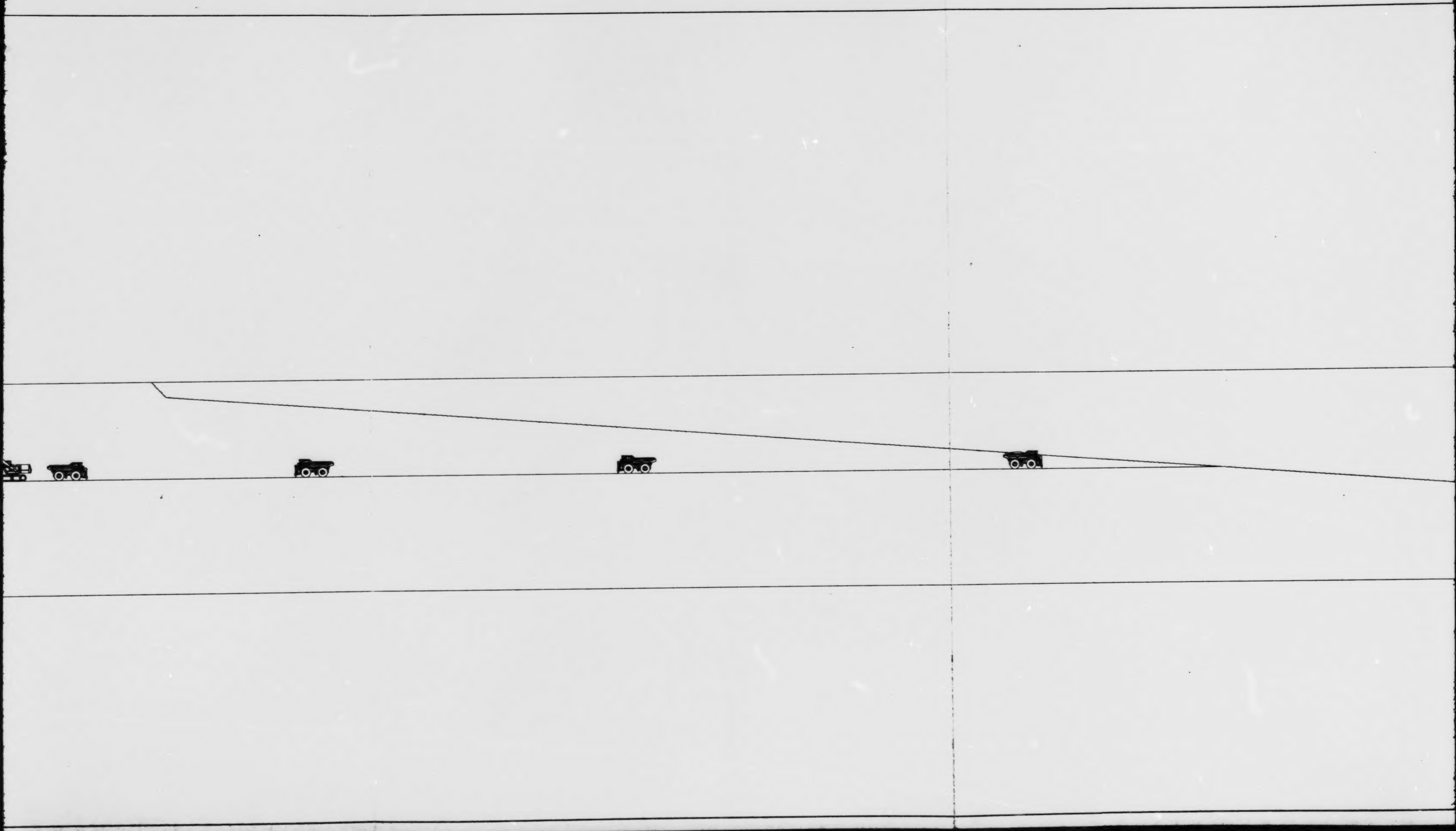
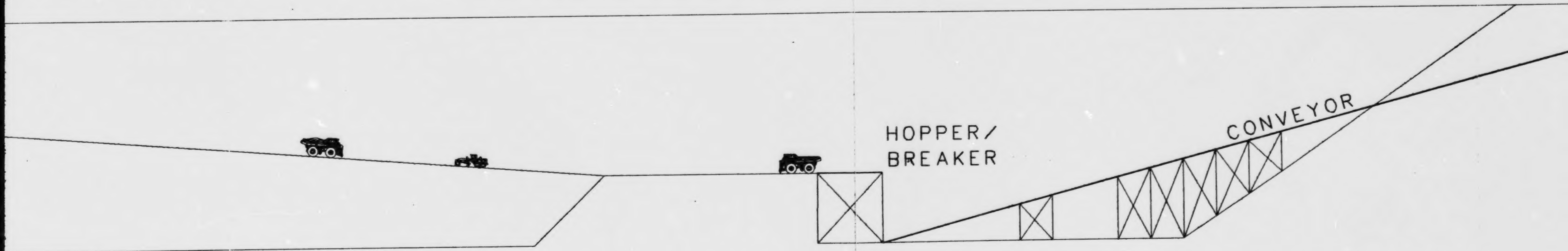
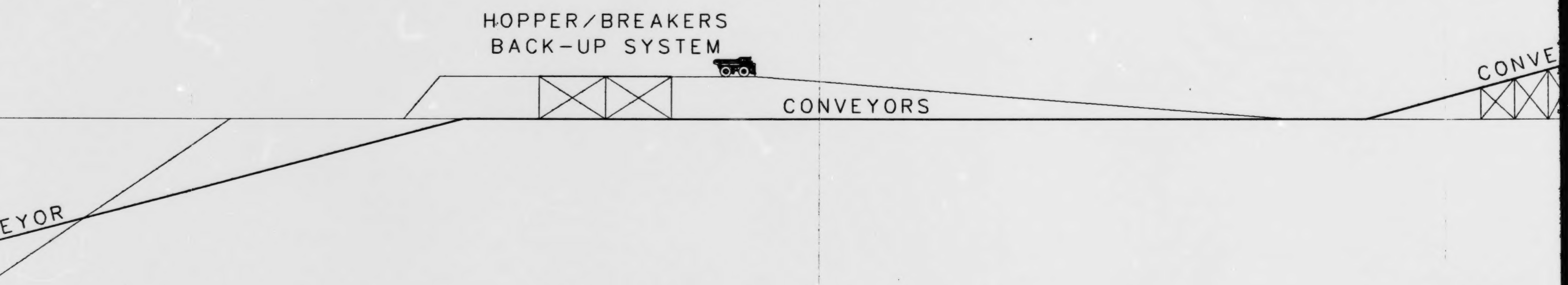
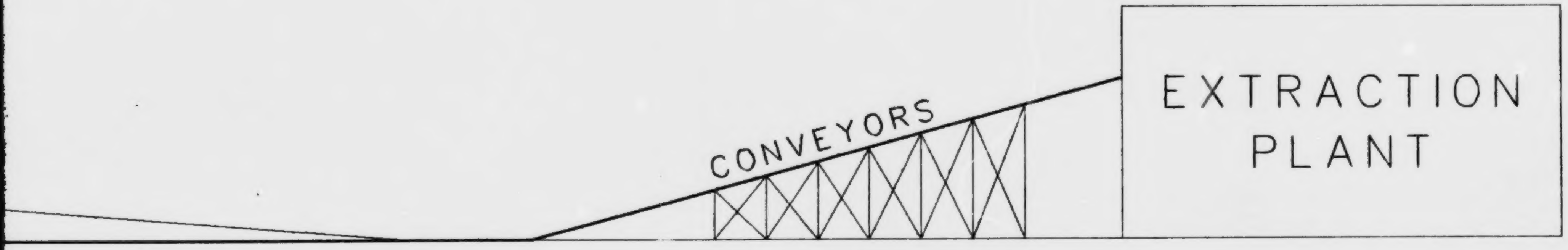
TARSO
FIGURE No. 4.2 – 3


TARSAND BENCH




HOPPER/
BREAKER
CONVEYOR


HOPPER/BREAKERS
BACK-UP SYSTEM
CONVEYORS
EYOR
CONVE



SCALE: 1 : 1000

CLIENT: GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME: ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
CASE 2
MINING MODULE – SECTION A – A'
TRUCK AND SHOVEL
15.9k m^3/CD (100,000 BPCD) BITUMEN

DRAWN BY: R.W.S.
CHECKED BY: J.H.
DATE: DEC. 1982
PROJECT No.: TM 500
DWG No.: TARSECTNAA
FIGURE No. 4.2 – 4

The hopper/breaker/conveyor system used in the initial years of the operation (located at the ground level next to the Extraction Plant) now functions as a back-up, and can be fed from both segments equally well.

When the first triangular part of the module is mined out (marked as Mining Limit Year 7.5 on Figure 4.2-1), the conveyor is extended over the waste dump to the centre of the module where the hopper/breaker is relocated. The position is marked as Year 7.5 - 15 Hopper/Breaker. A boxcut is opened radially out in the similar manner, as in the first part. Pie-shaped segments are mined in both directions away from the boxcut. The same procedure takes place in the other segments.

When the first half of the ore body has been mined out, a trunk conveyor is installed, connecting a transfer point at the centre of the ore body (marked as Conveyor Transfer Point Year 15) with the Extraction Plant. The above described procedure is then repeated, with the remaining modules being opened in the same manner as before, with the exception of the back-up system.

The hopper/breaker, conveyor and other equipment have been sized so that one module alone is capable of sustaining the required production. Two modules operated concurrently allow for more flexibility, reliability and better plant feed grade balancing. With mobile equipment, the mining can shift from place to place, rapidly.

Selective mining has not been addressed quantitatively in this study, however, several benefits are expected from hydraulic shovels and their capability of selective mining:

- increase in the bitumen saturation of the tarsand supplied to extraction;
- increase in bitumen recovery in the extraction due to a hydraulic shovel's ability to eliminate clay bands from the plant feed; and
- reduction in the tailings pond size through lower volume of sludge as a result of less fines in the plant feed.

The truck and shovel mining scheme is based on the utilization of good roads, therefore, availability of road building material is of the utmost importance. For the purpose of this study it was assumed that granular resources are located close to the mine, or that limestone will be at or close to the pit bottom. After the initial construction of the road network, mobile equipment maintains and relocates the roads as mining progresses. The fleet also provides road building material make-up, to offset rehandling losses.

The tailings disposal system and the recycle water system are the same as in Case 1.

The basic features of this mining scheme can be summarized as follows:

- modular approach;
- radial mining of each module;
- many module combinations possible to suit ore body and required capacity;
- minimize truck haulage;
- minimize conveyor length;
- maximize resource recovery through selective mining; and
- requirements for road building materials.

Equipment List:

- Hydraulic Shovels - eight required
  Demag H241 with 14m^3 bucket

- Hopper/Breakers (crushers) - three required
  throughput (each) = 11,000 t/h

- Belt Conveyor - two trains plus one back-up
  2,000 mm belt width, 4.5 m/sec belt speed
  conveyor length total: 0.4 km Year 1
  7.2 km Year 25

- Trucks
  Wabco 170 ton - 31 required
  Cat 777 (85 ton) - three required

- Front-End-Loaders - two required
  Cat 992

- Dozers
  Cat D-10 - six required
  Cat D-9L - 11 required

- Graders - four required
  Cat 16G

4.2.3 Material Balance

The same material balance as in Case 1 was assumed for Case 2.

4.2.4 Energy Requirements

Power requirements for the mine are as follows:

Peak Power -

Mine (conveyors, crushers)	11.1 MW
Misc. mine	3.0 MW
	14.1 MW

Average Power -

Mine and mine misc. (estimated)	11.0 MW

The mobile equipment fleet in the mine and the tailings disposal system is estimated to require 26.7 x 10^6 litres of diesel fuel per year.

4.2.5 Development of Costs

To achieve a meaningful cost comparison between the cases, the same general principles and assumption applied. As with Case 1, capital costs for major items were based on recent quotations while the contract cost and operating costs for the equipment were based on in-house data and experience.

For the cost centres where there was no apparent difference from Case 1 (as was assumed for tailings disposal system) the same cost was applied.

4.3 Case 3 Mining Scheme - 4k m^3/CD (25,000 BPCD) Bitumen, Truck/Shovel

4.3.1 Introduction

The mining scheme for Case 3 is a smaller version of Case 2, or conversely, Case 2 mining scheme is a multi-module application of the Case 3 mining scheme. The advantages of truck and shovel mining stated for Case 2 also hold true for Case 3. In addition, Case 3 features a much lower initial capital outlay for the mine, the lowest for all cases, making financeability less of a problem.

4.3.2 System Outline

The mining scheme developed for this case is based on the application of hydraulic shovels such as the Demag H241, 170 ton trucks, hopper/breakers (crushers) and a belt conveyor. The mine layout shown in Figure 4.3-1, Mining Schematic - Plan makes use of the same principles as Case 2:

- radial mining of the module;
- minimizing truck haulage;
- minimizing conveyor length; and
- selective mining with hydraulic shovels.

The sequence of pit opening described in Section 4.2.2 (Case 2) applies in this case also. The hopper/breaker located at the ground level close to the Extraction Plant is used for initial production and later on as a back-up system. The permanent hopper/breaker located at the pit bottom remains in its location for the duration of mine life.

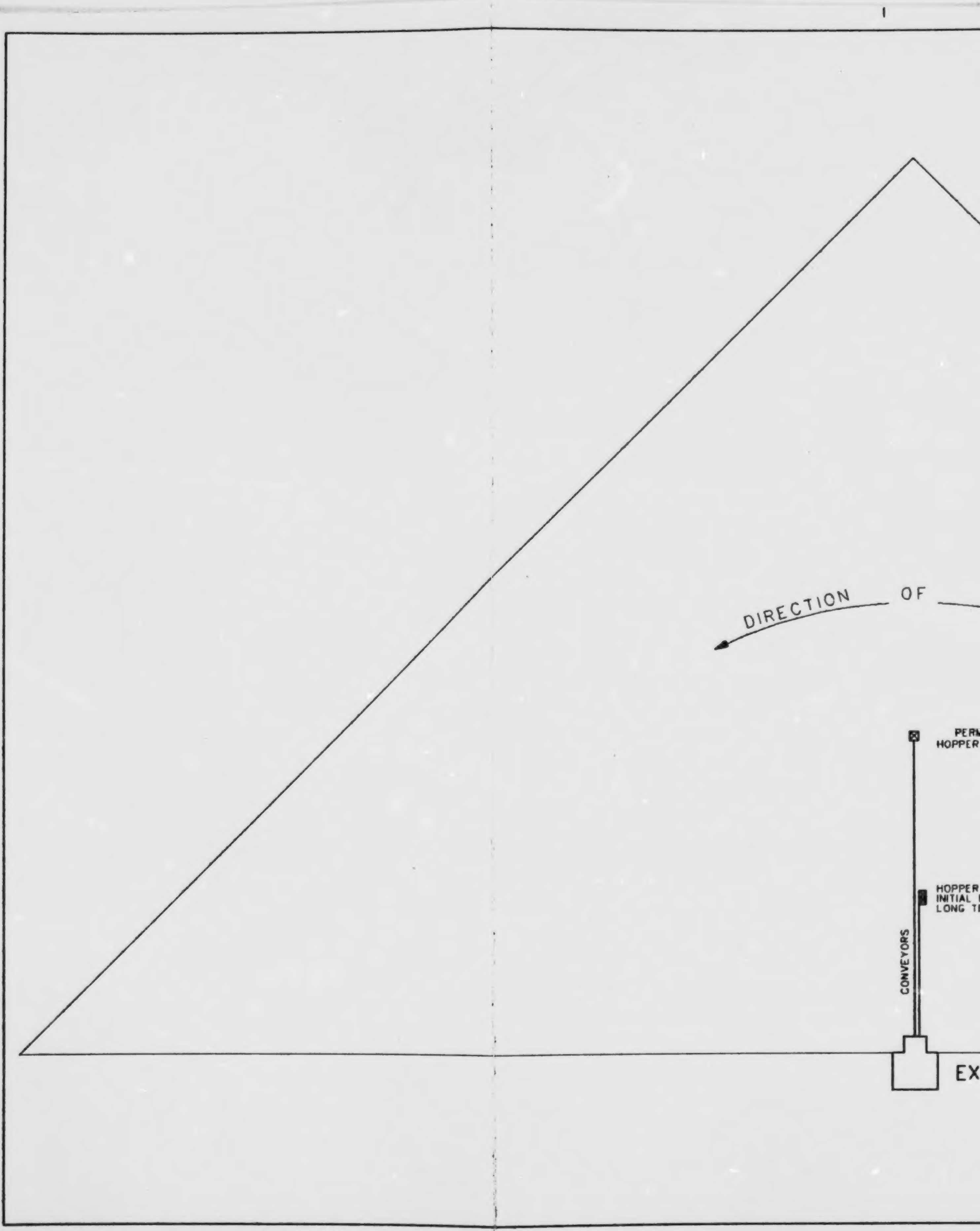
The radial mining of a module illustrated and described under Case 2 (Figures 4.2-2, 4.2-3, 4.2-4 and Section 4.2.2) is very similar to this case. The major differences are as follows:

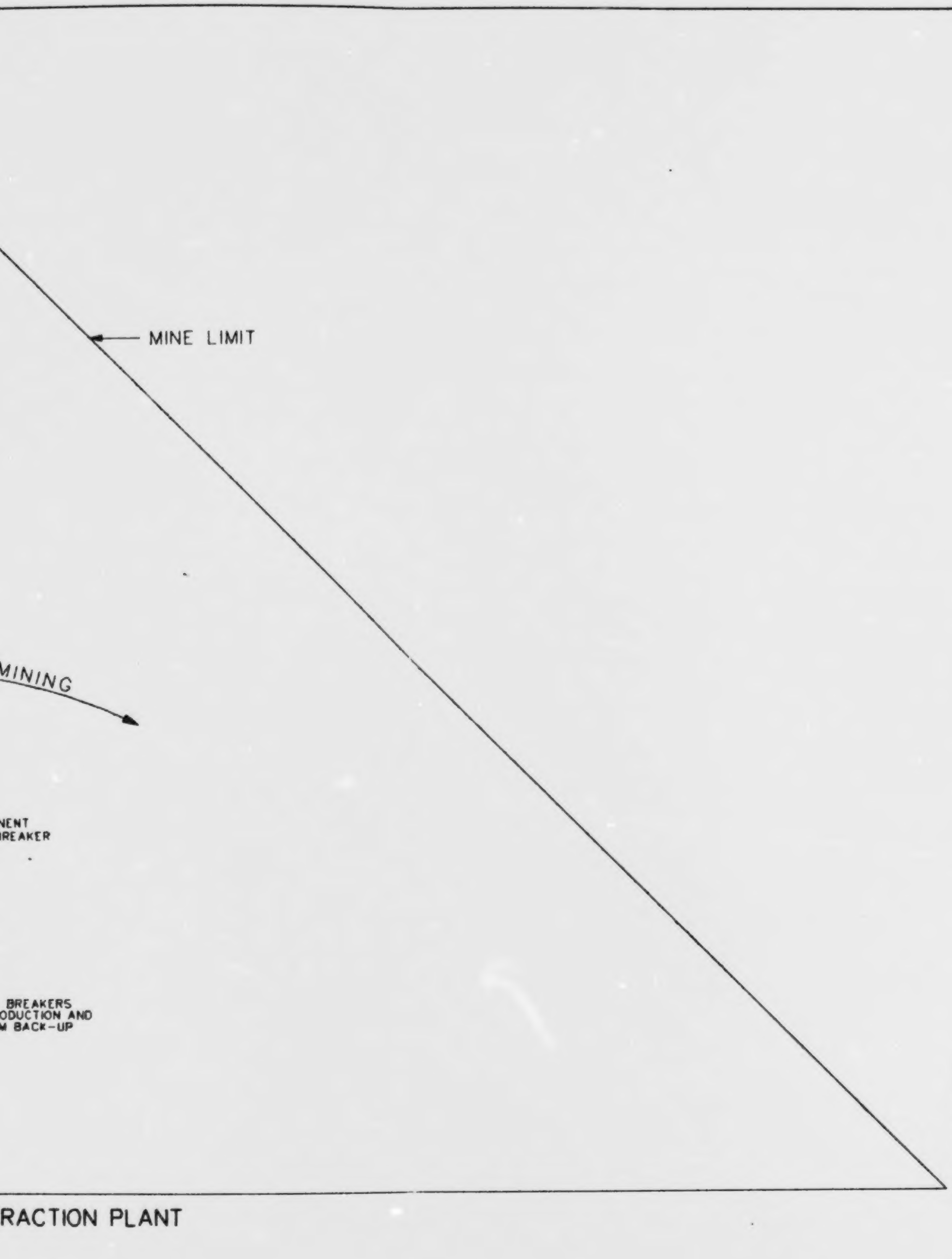
- only one module mined;
- one hopper/breaker-conveyor system for normal production, plus one hopper/breaker-conveyor system as back-up; and
- the hopper/breaker-conveyor system does not relocate or extend during the life of the mine.

The tailings disposal system was prorated from that of Case 1 and 2.

Equipment List:

- Hydraulic Shovels - three required
  Demag H241 with 14m^3 bucket
- Hopper/Breakers (crushers) - two required
  throughput (each) = 3 000 t/h
- Belt conveyor - one train plus one back-up
  1,600 mm belt width, 4.5 m/sec belt speed
  10° surcharge, 45° equal length idlers
  conveyor length total: 0.4 km Year 1
  1.1 km Year 25
- Trucks
  Wabco 170 ton - 10 required
  Cat 777 (85 ton) - two required


DIRECTION OF
PERM
HOPPER
HOPPER
INITIAL
LONG T
CONVEYORS
EX


MINE LIMIT
MINING
NENT
REAKER
BREAKERS
ODUCTION AND
M BACK-UP
RACTION PLANT

1 : 10000

GOVERNMENT OF
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ALTERNATE TARSANDS DEVE

CASE 3
MINING SCHEMATIC
TRUCK AND SH
4k m³/CD (25,000 BP

R.W.S.	J.H.	DEC
		FIGUR

1 : 10000

GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

ALTERNATE TARSANDS DEVELOPMENT STUDY

CASE 3
MINING SCHEMATIC – PLAN
TRUCK AND SHOVEL
4k m^3/CD (25,000 BPCD) BITUMEN

R.W.S.	J.H.	DEC. 1982	TM 500

TARSCHPLAN

FIGURE No. 4.3 – 1

- Front-End-Loaders - one required
  Cat 992

- Dozers
  Cat D-10 - two required
  Cat D-9L - three required

- Graders - two required
  Cat 16G

4.3.3 Material Balance

During an average year (steady state full production) of operation, the mine and tailings disposal will handle the quantities of material as follows:

Muskeg stripping	0.4×10^6 BCM/yr
Overburden stripping	1.6×10^6 BCM/yr
Tarsand (plant feed)	6.8×10^6 BCM/yr
Centre reject	1.8×10^6 BCM/yr
Total pumped tailings	15.9×10^6 m^3/yr
sand	7.3×10^6 m^3/yr
sludge	2.5×10^6 m^3/yr
recycle water	6.1×10^6 m^3/yr

4.3.4 Energy Requirements

Power requirements for the mine are as follows:

Peak Power -

Mine (conveyors, crushers)	2.7 MW
Misc. mine	1.0 MW
	3.7 MW

Average Power -

Mine and mine misc. (estimated) 2.7 MW

The mobile equipment fleet in the mine and the tailings disposal system is estimated to require 6.7 x 10^6 litres of diesel fuel per year.

4.3.5 Development of Costs

The capital, contract and operating cost for Case 3 were factored from the developed costs of Case 1 and 2.

4.4 Case 4 Mining Scheme - 4k m^3/CD (25,000 BPCD) Bitumen, BWE/Dragline

4.4.1 Introduction

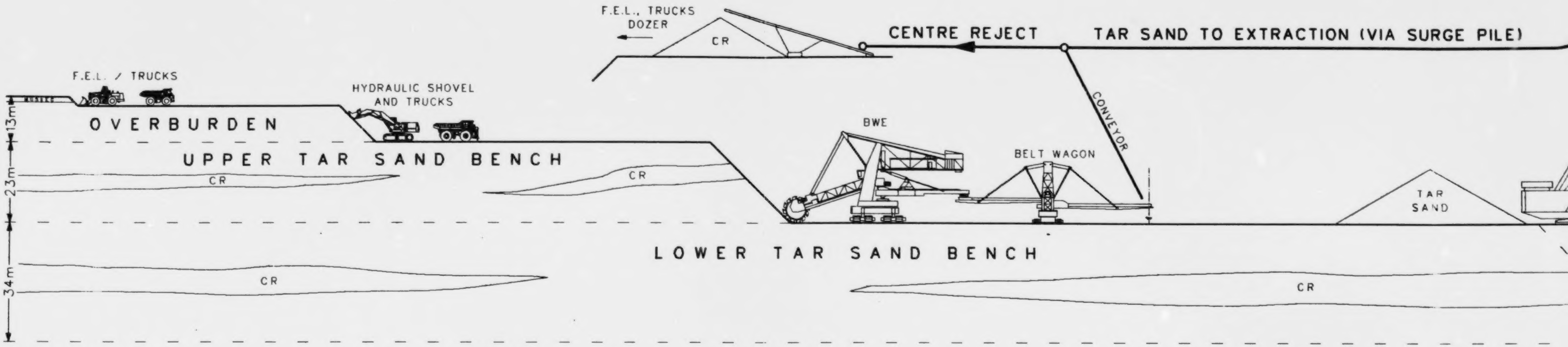
The suitability of large mining equipment, such as bucketwheel excavators and draglines, to a mining scheme as small as a 4k m^3/CD (25,000 BPCD) of bitumen scheme has been of concern. The scheme developed for this case makes use of one bucketwheel excavator and one dragline suitably sized for a tarsand mine. The scheme, as presently scoped, suffers from relatively large initial capital, lack of operating flexibility, and a single train concept. It is believed that this scheme could be improved by using two or more trains with smaller equipment. This would result in increased flexibility but would also increase the initial capital cost.

4.4.2 System Outline

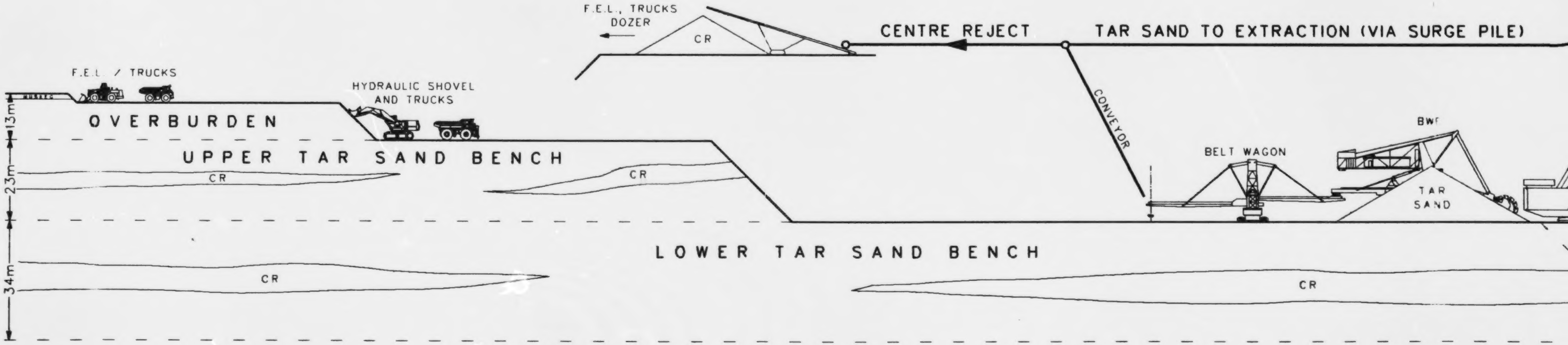
The most significant feature of this scheme is a "one train" concept. As in the extraction and in the upgrading, only one line is supplying the product from the mine. The BWE, belt wagon and conveyor form this "line". The BWE excavates tarsand and centre reject, which is disposed of in the same manner as in Case 1 and, therefore, cannot supply tarsand at the same time. However, the BWE operating in the terrace cut mode should not stay in reject for more than two hours, a duration which can be easily covered by tarsand stored in the live portion of the surge pile. When the BWE operates in a very thick layer of centre reject, tarsand will have to be dozed into the dump pocket from the dead portion of the surge pile. This source of tarsand must also be utilized when the face conveyor is being shifted, a task which should be completed in two days. However, when a prolonged supply outage results, as during the BWE's major repair (approximately two months), hydraulic shovels, FEL's and trucks normally operating in overburden stripping, centre reject disposal and granular resources, will have to be called upon to assure an uninterrupted supply of tarsand to extraction. Additional units may be brought in under an outside contract. The mobile equipment can supply the emergency feed from the dragline windrow or directly from the upper tarsand bench.

Upon completion of its pass in the upper tarsand bench, the BWE and the belt wagon will move to the other side of the face conveyor, where the dragline places the tarsand in windrows from the lower tarsand bench, backcasting centre reject into the mined-out pit. The BWE loads windrowed tarsand onto the face conveyor belt. This, the second phase of operation, takes approximately five months (assuming a two kilometre long mining face). Timing and interaction of the two major excavators is important. The scheme is illustrated in three drawings, Figure 4.4-1 shows two different modes of operation in section, Figure 4.4-2 shows a plan of phase 1 (BWE in the upper tarsand bench), and Figure 4.4-3 shows a phase 2 (BWE in dragline windrow). Looking at the plan view of the mining schematic - Figure 4.4-2, and assuming north is up, the BWE starts its pass at the northend, and at the same time the dragline starts its pass at the south end. At the end of the BWE pass (i.e, when BWE reaches the south end) the dragline windrow is 46 percent complete. The BWE moves around the tail end of the face conveyor and starts reclaiming the windrow. Both the BWE and dragline should reach the north end of the mining face at approximately the same time, as illustrated on the mining schematic shown in Figure 4.4-3. The BWE moves to its original location (upper tarsand bench, north end) via a gate conveyor, while the dragline walks to the south end to commence a new cycle.

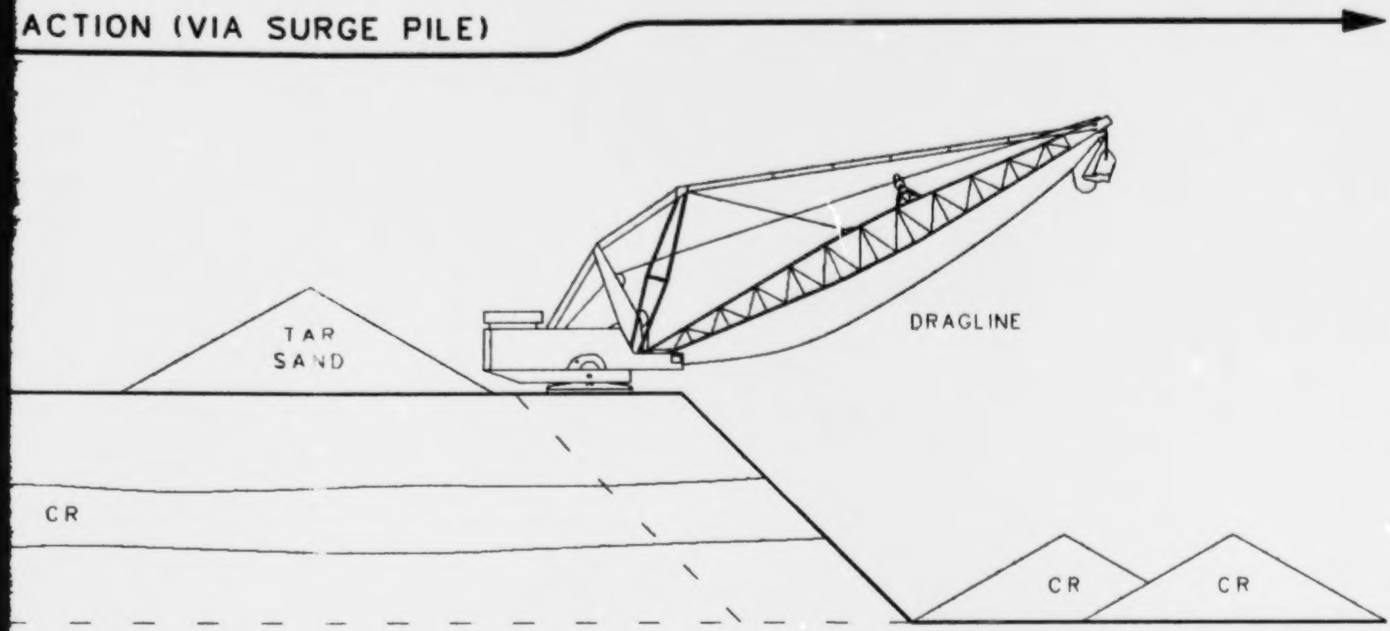
Overburden stripping and centre reject disposal system are similar to that employed in Case 1.


F.E.L., TRUCKS
DOZER
CR
CENTRE REJECT
TAR SAND TO EXTRACTION (VIA SURGE PILE)
F.E.L. / TRUCKS
HYDRAULIC SHOVEL
AND TRUCKS
CONVEYOR
13m
OVERBURDEN
BWE
UPPER TAR SAND BENCH
BELT WAGON
23m
CR
CR
TAR
SAND
LOWER TAR SAND BENCH
34m
CR
CR

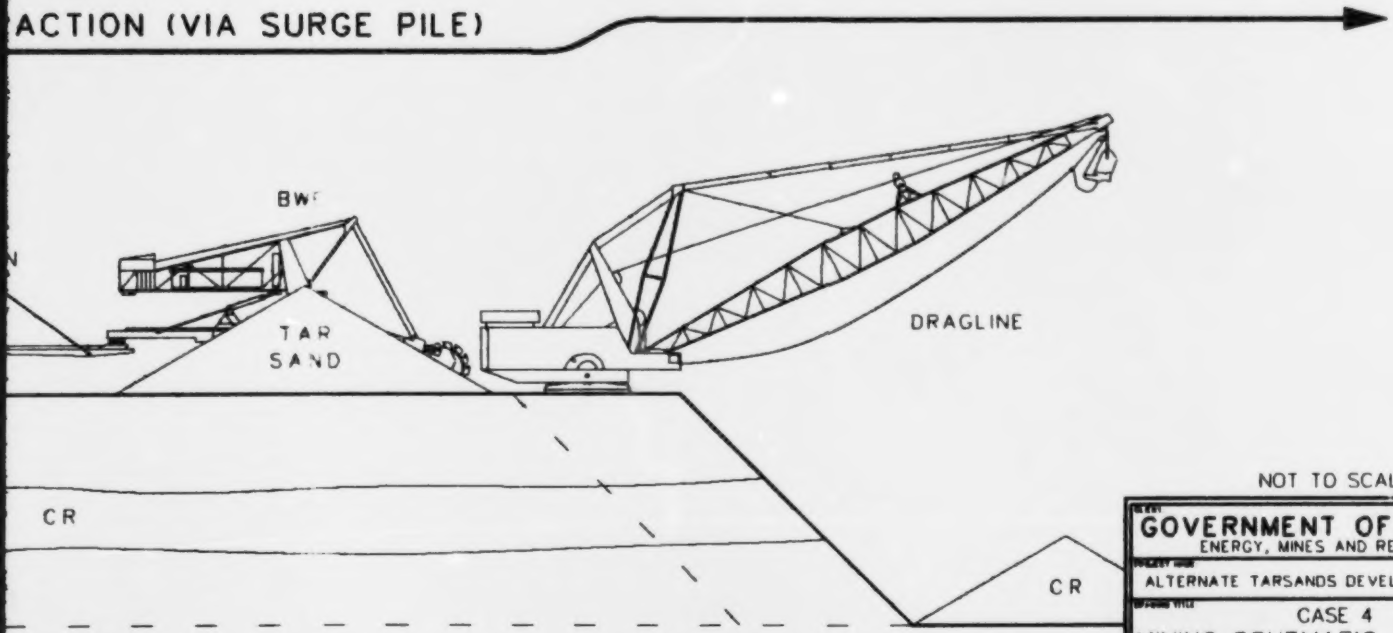
PHASE 1 - BWE IN UPPER TAR SAND BENCH (4 MONTHS DURATIO


F.E.L., TRUCKS
DOZER
CR
CENTRE REJECT
TAR SAND TO EXTRACTION (VIA SURGE PILE)
F.E.L. / TRUCKS
HYDRAULIC SHOVEL
AND TRUCKS
CONVEYOR
13m
OVERBURDEN
BWE
BELT WAGON
UPPER TAR SAND BENCH
23m
CR
CR
TAR
SAND
LOWER TAR SAND BENCH
34m
CR
CR

PHASE 2 - BWE IN TAR SAND WINDROW (5 MONTHS DURATION)


ACTION (VIA SURGE PILE)
TAR SAND
DRAGLINE
CR
CR
CR

MONTHS DURATION)


ACTION (VIA SURGE PILE)
BW
TAR SAND
DRAGLINE
CR
CR

NTHS DURATION)

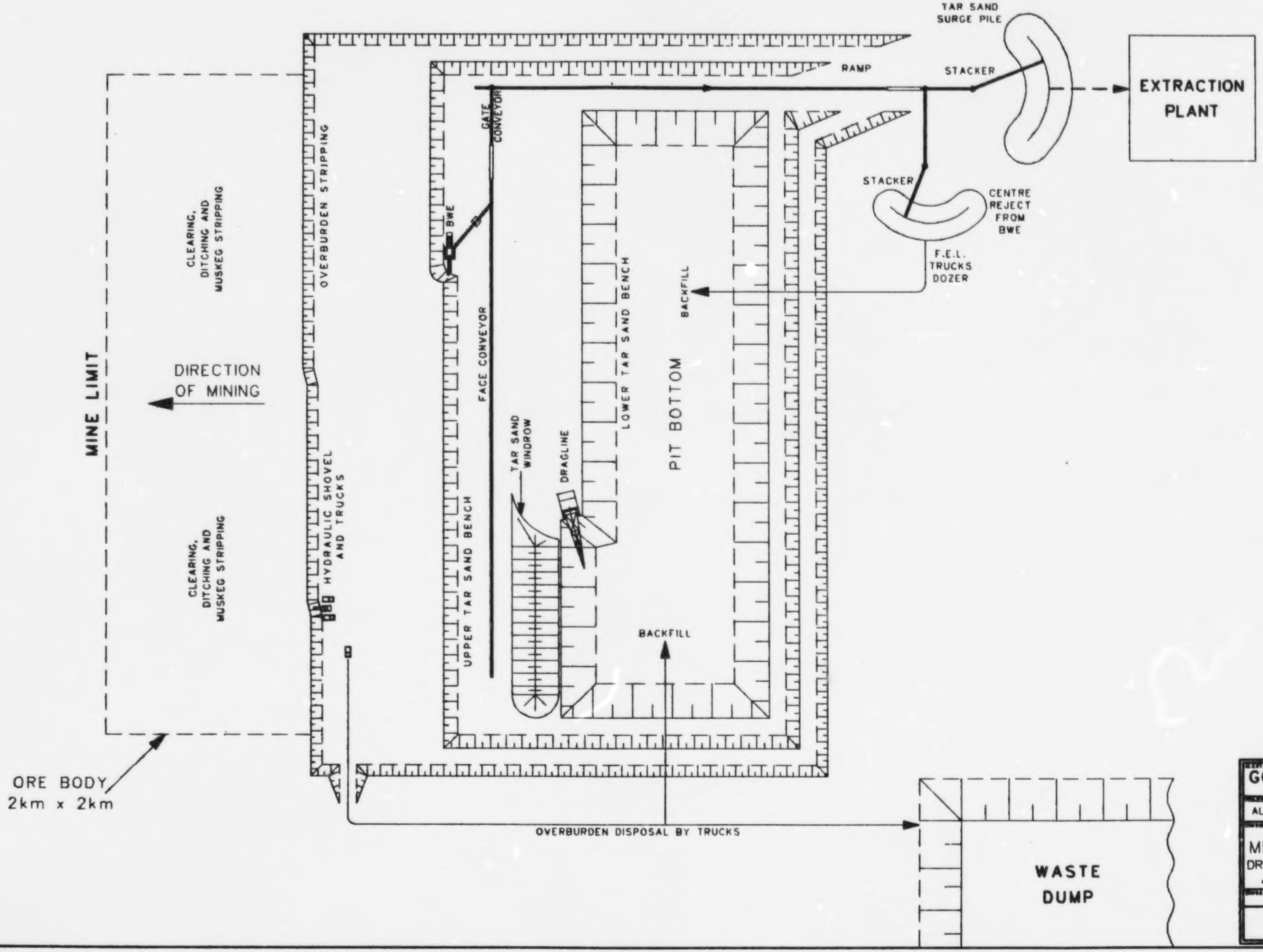
NOT TO SCALE

GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
ALTERNATE TARSANDS DEVELOPMENT STUDY
CASE 4
MINING SCHEMATIC – SECTION
DRAGLINE/BUCKET WHEEL EXCAVATOR
4k m³/CD (25,000 BPCD) BITUMEN

R.W.S.	J.H.	DEC. 1982	TM 500

TARSCHM25
FIGURE No. 4.4 – 1

PHASE 1 – BWE IN UPPER TAR SAND BENCH (4 MONTHS DURATION)


TAR SAND
SURGE PILE
RAMP
STACKER
EXTRACTION
PLANT
GATE CONVEYOR
STACKER
CENTRE
REJECT
FROM
BWE
F.E.L.
TRUCKS
DOZER
BWE
CLEARING, DITCHING AND MUSKEG STRIPPING
OVERBURDEN STRIPPING
FACE CONVEYOR
LOWER TAR SAND BENCH
BACKFILL
MINE LIMIT
DIRECTION
OF MINING
PIT BOTTOM
TAR SAND WINDROW
DRAGLINE
HYDRAULIC SHOVEL AND TRUCKS
CLEARING, DITCHING AND MUSKEG STRIPPING
UPPER TAR SAND BENCH
BACKFILL
ORE BODY
2km x 2km
OVERBURDEN DISPOSAL BY TRUCKS
WASTE
DUMP

NOT TO SCALE

GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

ALTERNATE TARSANDS DEVELOPMENT STUDY

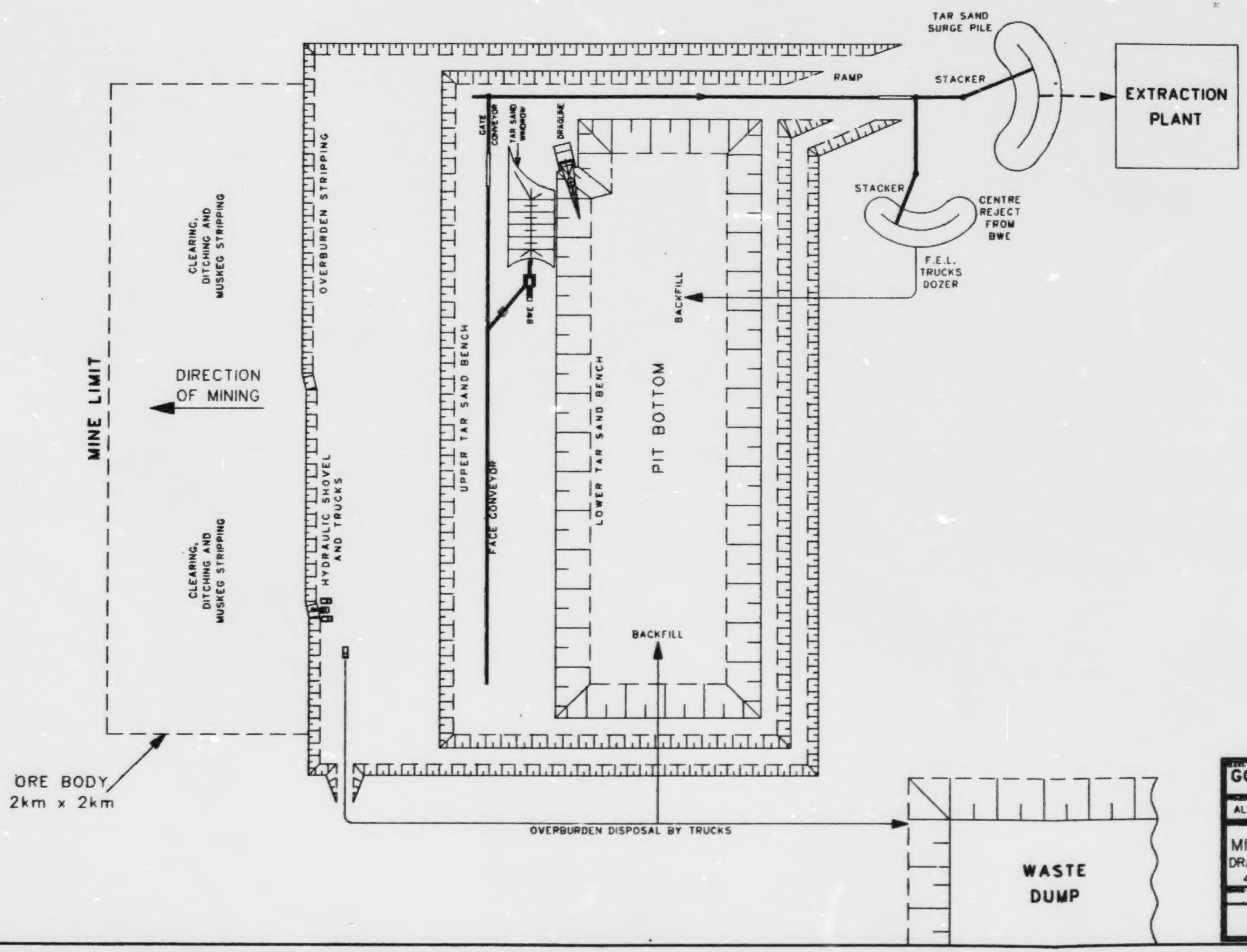
CASE 4
MINING SCHEMATIC – PLAN
DRAGLINE/BUCKET WHEEL EXCAVATOR
4k m³/CD (25,000 BPCD) BITUMEN

R.W.S. | J.H. | DEC. 1982 | TM 500

TARSCH25P1

FIGURE No. 4.4 – 2

PHASE 2 - BWE IN TAR SAND WINDROW (5 MONTHS DURATION)


TAR SAND SURGE PILE
RAMP
STACKER
EXTRACTION PLANT
GATE CONVEYOR
TAR SAND WINDROW
DRAGLINE
STACKER
CENTRE REJECT FROM BWE
F.E.L. TRUCKS DOZER
BACKFILL
BWE
OVERBURDEN STRIPPING
CLEARING, DITCHING AND MUSKEG STRIPPING
UPPER TAR SAND BENCH
LOWER TAR SAND BENCH
PIT BOTTOM
MINE LIMIT
DIRECTION OF MINING
FACE CONVEYOR
HYDRAULIC SHOVEL AND TRUCKS
CLEARING, DITCHING AND MUSKEG STRIPPING
BACKFILL
ORE BODY 2km x 2km
OVERBURDEN DISPOSAL BY TRUCKS
WASTE DUMP

NOT TO SCALE

GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

ALTERNATE TARSANDS DEVELOPMENT STUDY

CASE 4
MINING SCHEMATIC - PLAN
DRAGLINE/BUCKET WHEEL EXCAVATOR
4k m³/CD (25,000 BPCD) BITUMEN

R.W.S.	J.H.	DEC. 1982	TM 900

TARSCH25P2

FIGURE No. 4.4 - 3

Equipment List:

- Dragline - one required
  Marion 7820-24 with 84 m boom at 30°
  bucket size = 24 m^3
  working weight = 1.79×10^6 kg

- Bucket Wheel Excavator - one required
  functions also as a reclaimer
  "C" frame, approx. weight 1700 t
  average capacity $Q_{a.g}$ = 1750 BCM/h
  effective capacity Q_{eff} = 2460 BCM/h
  theoretical capacity Q_{th} = 4320 loose m^3/h

- Belt Wagon - one required
  length = 67 m
  approx. weight = 600 t

- Belt Conveyor - one train
  1800 mm belt width, 4.0 m/sec belt speed
  10° surcharge, 45° equal length idlers
  required maximum capacity Q_c = 5190 loose m^3/h
  conveyor length total - 2.7 km Year 1
  4.7 km Year 25

- Hydraulic Shovel - one required
  O & K RH75 with 7 m^3 bucket

- Trucks - 11 required
  Cat 777 (85 ton)

- Front-End-Loaders - two required
  Cat 992

- Dozers
  Cat D-10 - five required
  Cat D-9L - four required

- Graders - two required
  Cat 16G

4.4.3 Material Balance

The same yearly material balance for the mine and tailings disposal was assumed as that in Case 3, which is 25 percent of the base case (Case 1).

4.4.4 Energy Requirements

Power requirements for the mine are as follows:

Peak power -

Mine (BWE, DL, Conveyor)	13.5 MW
Mine misc.	2.0 MW
	15.5 MW

Average power -

Mine (BWE, DL, Conveyor)	9.5 MW
Mine misc.	2.0 MW
	11.5 MW

The power calculation is based on a 90 percent probability as described in Case 1.

The mobile equipment fleet in the mine and the tailings disposal system is estimated to require 3.5 x 10^6 litres of diesel fuel per year.

4.4.4 Development of Costs

The costing for Case 4 was done by cost centres. The major equipment was costed individually in cost centres whereas factoring of costs developed for Case 1 was used for most other items.

4.5 Case 5 Mining Scheme, 4k m^3/CD (25,000 BPCD) - 15.9k m^3/CD (100,000 BPCD) Bitumen, Truck/Shovel

4.5.1 Introduction

A comparative, albeit preliminary, analysis of capital and operating costs indicated a trend favouring the truck and shovel operation over the bucket wheel and dragline, even at the 15.9k m^3/CD (100,000 BPCD) bitumen production level. Based on this analysis, it was decided, that the build-up cases - Case 5 and Case 6, would employ trucks and shovels during the start-up years as well as during the full production years, i.e., at 15.9k m^3/CD (100,000 BPCD) of bitumen. The optional mining scheme - starting with trucks and shovels, and then adding bucketwheels and draglines later on has not been developed at this stage because of the above mentioned trends in capital and operating costs. It is suspected that one of the reasons for this apparent change in economics is due to recent developments and advancements in mobile mining technology. This represents a significant departure from the historic approach and will require much further development and substantiation in Stage II.

4.5.2 System Outline

The mining scheme developed for Case 5 is based on the Case 2 mine layout and equipment. Due to lower initial throughput requirements, only one module would be opened during the first five years of production. The same small fleet of mobile equipment, as in Case 3, would be required. As the production requirements increase in Year 6 to Year 11, trucks, hydraulic shovels and other mobile equipment are added to match the fleet of Case 2. The full production configuration is based on two modules operated concurrently. As in Case 2, the modules and the equipment are sized so that one module alone can provide a sufficient stream of tarsand to keep the extraction plant operating at the required capacity.

A site specific tailings pond needs to be developed for a mining scheme such as this. It has been assumed that during the initial years of operation a small scale tailings disposal scheme would be developed, such as in Case 3 and 4, which then could be expanded into a larger scale system, such as in Case 1 and 2 when production reaches the 15.9k m^3/CD (100,000 BPCD) of bitumen level.

Equipment List

Up to Year 6 - see Case 3
Year 6 and on - see Case 2

4.5.3 Material Balance

Up to Year 6 - see Case 3
Year 6 and on - see Case 2

4.5.4 Energy Requirements

Up to Year 6 - see Case 3
Year 6 and on - see Case 2

4.5.5 Development of Costs

The mine and tailings disposal costs for the slow start-up cases (Case 5 and 6) were based on Case 3 in the preproduction and initial years. The transition into the full capacity operation was accounted for by factoring out Case 2 development costs. The capital, operating and contract costs for full 15.9k m^3/CD (100,000 BPCD) of bitumen production are the same as Case 2.

4.6 Case 6 Mining Scheme - 4k m^3/CD (25,000 BPCD) - 15.9 m^3/CD (100,000) BPCD Bitumen, Truck/ Shovel

The mining scheme developed for Case 6 is an exact duplication of Case 5, as it was assumed that the remoteness of the upgrading facilities will have no impact on the method of mining.

4.7 Case 7 Mining Scheme - 8k m^3/CD (50,000 BPCD) Bitumen, Truck/Shovel

A truck and shovel mining scheme similar to that for Case 2 and Case 3 has been selected for the 8k m^3/CD (50,000 BPCD) bitumen operation. The mining scheme selection was based on cost trends indicated in a comparison of the first four cases. Since it has been demonstrated that the truck and shovel mining scheme as developed in the study is operable at both the 4k m^3/CD (25,000) and 15.9k m^3/CD (100,000 BPCD) of bitumen production level, much less detail has been devoted to the development of a mining scheme for Case 7 and 8, which is at the mid-point between Cases 2 and 3.

The mine layout is identical to one half of that shown for Case 2 (Figure 4.2-1). The modules located closest to the Extraction Plant form the 8k m^3/CD (50,000 BPCD) mine. Only one module would be mined at a time.

4.8 Case 8 Mining Scheme - 8k m^3/CD (50,000 BPCD) Bitumen, Truck/Shovel

The mining scheme developed for Case 8 is an exact duplication of Case 7, as it was assumed that the remoteness of the upgrading facilities will have no impact on the method of mining.

4.9 Case 9 Mining Scheme - 15.9k m^3/CD (100,000 BPCD) Bitumen, Truck/Shovel

The mining scheme developed for Case 9 is an exact duplication of Case 2, as it was assumed that remoteness of the upgrading facilities will have no impact on the method of mining.

APPENDIX D

EXTRACTION SCHEMES

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- 1.6 Froth Treatment 3

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1.0 PROCESS DESCRIPTION

1.1 General

For the alternate schemes selected in Stage I, the Extraction Design is based on the K.A. Clark Hot Water Process. The process layout is shown in Figure 1.1-1 and is made up of the following major units:

- surge and feed system;
- conditioning;
- primary separation;
- middlings treatment; and
- froth treatment.

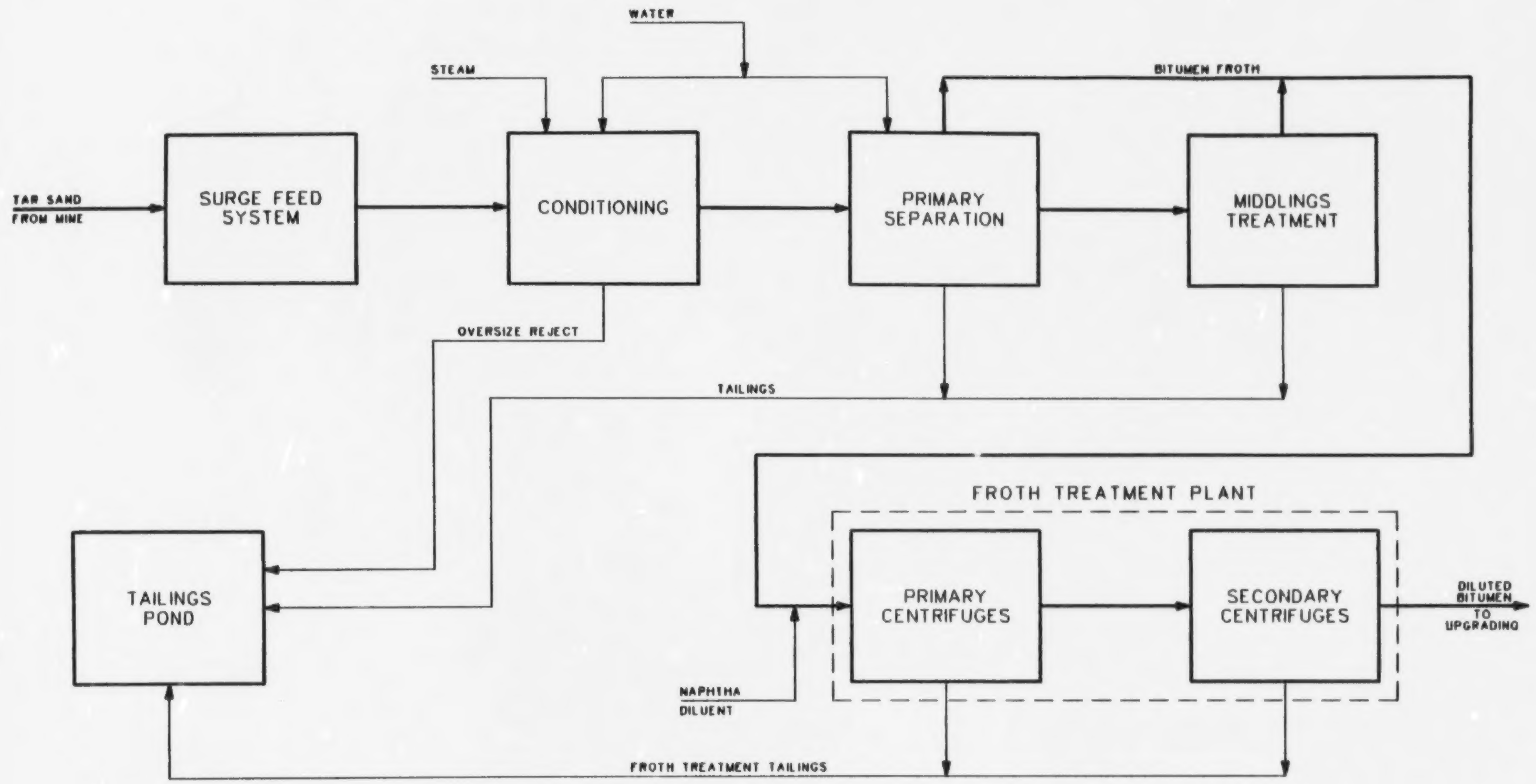
The units as described below are used in each case. The number of trains and/or the capacity rating of the components are varied to meet the bitumen production requirement.

1.2 Surge and Feed System

In the conceptual design, a stockpile fed by stackers or tripper conveyors is included. The purpose of this system is to delink the mine and extraction operations with ore storage. A few hours of live storage is envisioned with a day or two of dead storage reclaimable by bulldozers. The stored material is discharged to apron feeders and fed by conveyor belts into the processing plant for extraction.

1.3 Conditioning

Conditioning involves combining tarsand with hot water (85°C), caustic soda and low pressure steam in a rotating drum to produce a slurry mixture of sand, dispersed bitumen and water. This processing step prepares the tarsand feed for separation by the subsequent process units. The conditioned slurry is discharged over screens that remove oversize rocks and clay lumps which are then transported to the mined out area or tailings pond.


TAR SAND
FROM MINE
SURGE FEED SYSTEM
STEAM
WATER
CONDITIONING
PRIMARY SEPARATION
BITUMEN FROTH
MIDDLINGS TREATMENT
OVERSIZE REJECT
TAILINGS
TAILINGS POND
FROTH TREATMENT PLANT
PRIMARY CENTRIFUGES
SECONDARY CENTRIFUGES
DILUTED BITUMEN
TO UPGRADING
NAPHTHA
DILUENT
FROTH TREATMENT TAILINGS

NOTE: SEE TABLES 2.1-1, 2.2-1, 2.3-1,
2.4-1 AND 2.5-1 FOR THE DESIGN
BASIS FOR EACH CASE.

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
EXTRACTION AND
FROTH TREATMENT
SCHEMATIC

DRAWN BY	CHECKED BY	DATE	PROJECT No.:
T.F.W.	E.S.	12/07/82	TM-500
		DWG No.	TS5008022
			FIGURE 11-1

1.4 Primary Separation

Separation of dispersed bitumen from the slurry stream is accomplished in the primary separation vessel. As the conditioned slurry is added to this vessel, the coarse sand particles settle rapidly to the bottom and are raked continuously to a central discharge cone. The bitumen rises forming a frothy layer on top of the cell. This layer, referred to as primary froth, is skimmed off and pumped to the froth treatment plant.

The fines, consisting mainly of silt and clays, do not settle out and tend to accumulate in the middle zone of the separation cell. This zone must be continuously withdrawn and bitumen included with this stream is further treated in a middlings treatment circuit.

1.5 Middlings Treatment

The conventional middlings treatment circuit uses flotation cells. Air is injected into the middlings, and with mechanical agitation a bituminous froth is formed. This froth is combined with the primary froth and pumped to the froth treatment plant.

Tailings from both the middlings treatment circuit and the primary separation vessel are combined and pumped to the tailings pond.

1.6 Froth Treatment

The froth treatment plant treats the combined froth from the primary separation plant. This plant utilizes two stages of dilution centrifuging with diluent naphtha addition to obtain the product specifications required for the upgrading units.

2.0 CASE DESCRIPTIONS

2.1 Cases 1 and 2

The extraction facilities for these cases are designed to process 6464 tonnes per calendar hour of tarsand feed. This feed rate will be processed in three trains of equipment of similar size to the largest commercially used units.

To achieve the required calendar hour production rate, a stream factor of 0.70 has been applied to account for extraction mechanical breakdown and maintenance, and interdependencies between mining, utilities, upgrading and the extraction facilities. A stream factor of 0.70 is similar to that currently used in extraction facilities at operating plants of this size.

For all cases in this study, a constant 11.5 percent bitumen grade with an overall recovery of 90 percent has been used. These values are characteristic of grades and recoveries found in practice with present operations. Improvements in bitumen recovery are being pursued with alternative technology but commercial application has yet to be made. Higher average bitumen grades may be achieved with more selective mining techniques.

The design basis used in this study is summarized in Table 2.1-1.

2.2 Cases 3 and 4

The extraction facilities for these cases are designed to process 1616 tonnes per calendar hour of tarsand feed. This feed rate will be processed in one train of equipment. The single equipment units in this train would be the feed conveyor, conditioning drum and separation vessel. The other major processing equipment units in the extraction facilities would be multiple units.

To achieve the required calendar hour production rate, a stream factor of 0.65 has been applied. This lower stream factor reflects the higher

Table 2.1-1

Design Basis for Cases 1 and 2

Process Component	Calendar Rate	Stream Rate
Plant Production of Bitumen (m^3/d)	15900	22700
Bitumen Grade (%)	11.5	11.5
Bitumen Recovery (%)	90.0	90.0
Extraction Stream Factor	0.70	0.70
Ore Feed Rate - Plant (t/h)	6464	9234
- Train (t/h)	2155	3078
Number of Trains	3	3
Utilities Demands		
Steam (50 #) (t/h)	355	507
Hot Water (85°C) (m^3/h)	2586	3694
Electrical (MW)	30	43
Diluent (t/h)	470	671
Diluent Losses (t/h)	10	14

interference between mining, utilities, upgrading and extraction because of the single train concept in the extraction facilities.

The design basis used in this study is summarized in Table 2.2-1.

2.3 Cases 5 and 6

The extraction facilities for these cases would be designed to expand from a one train facility to a three train facility. To achieve the final production requirements, the initial equipment installation would be of the same size as that required in the expansion trains. To minimize the initial capital requirements, utilities steam and hot water would be supplied for approximately 80 percent of the initial train capacity.

In Case 6, the significant difference in the extraction facility operation is the utilities steam supply system required for conditioning and water heating, as no waste heat is available from the remotely located upgrader. Details of the utilities equipment requirements are in Appendix F.

The design basis used in this study is summarized in Table 2.3-1.

2.4 Cases 7 and 8

The extraction facilities for these cases are designed to process 3232 tonnes per calendar hour of tarsand feed. This feed rate will be processed in two trains of equipment of the same size used in Cases 3 and 4.

To achieve the required calendar hour production rate, a stream factor of 0.65 has been applied at this stage of the study.

In Case 8, the significant difference in the extraction facility operation is the utilities steam supply system. As the upgrader is

Table 2.2-1

Design Basis for Cases 3 and 4

Process Component	Calendar Rate	Stream Rate
Plant Production of Bitumen (m^3/d)	4000	6150
Bitumen Grade (%)	11.5	11.5
Bitumen Recovery (%)	90.0	90.0
Extraction Stream Factor	0.65	0.65
Ore Feed Rate - Plant (t/h)	1616	2486
- Train (t/h)	1616	2486
Number of Trains	1	1
Utilities Demands		
Steam (50 #) (t/h)	89	136
Hot Water (85°C) (m^3/h)	647	995
Electrical (MW)	7.5	11.5
Diluent (t/h)	118	182
Diluent Losses (t/h)	2.5	3.6

Table 2.3-1

Design Basis for Cases 5 and 6

Process Component	Calendar Rate		Stream Rate	
	Start	Finish	Start	Finish
Plant Production of Bitumen (m^3/d)	4000	15900	6150	22700
Bitumen Grade (%)	11.5	11.5	11.5	11.5
Bitumen Recovery (%)	90.0	90.0	90.0	90.0
Extraction Stream Factor	0.65	0.70	0.65	0.70
Ore Feed Rate - Plant (t/h)	1616	6464	2486	9234
- Train (t/h)	1616	2154	2486	3078
Number of Trains	1	3	1	3
Utilities Demands				
Steam (50 #) (t/h)	89	355	136	507
Hot Water (85°C) (m^3/h)	647	2586	995	3694
Electrical (MW)	7.5	30	11.5	43
Diluent (t/h)	118	470	182	671
Diluent Losses (t/h)	2.5	10	3.6	14.3

remotely located, no waste heat is available and all of the steam and hot water must be supplied by on-site utilities boilers (See Appendix F).

The design basis used in this study is summarized in Table 2.4-1.

2.5 Case 9

For Case 9, the extraction facilities are the same as in Cases 1 and 2. The feed will be processed in three trains of equipment to achieve the required production of bitumen.

Again, as in Cases 6 and 8, the utilities supplies to extraction have no waste heat from the remotely located upgrader and all the energy required is produced on-site (see Appendix F).

The design basis used in this study is summarized in Table 2.5-1.

Table 2.4-1

Design Basis for Cases 7 and 8

Process Component	Calendar Rate	Stream Rate
Plant Production of Bitumen (m^3/d)	8000	12300
Bitumen Grade (%)	11.5	11.5
Bitumen Recovery (%)	90.0	90.0
Extraction Stream Factor	0.65	0.65
Ore Feed Rate - Plant (t/h)	3232	4972
- Train (t/h)	1616	2486
Number of Trains	2	2
Utilities Demands		
Steam (50 #) (t/h)	178	272
Hot Water (85°C) (m^3/h)	1294	1990
Electrical (MW)	15	23
Diluent (t/h)	236	364
Diluent Losses (t/h)	5	7.2

Table 2.5-1

Design Basis for Case 9

Process Component	Calendar Rate	Stream Rate
Plant Production of Bitumen (m^3/d)	15900	22700
Bitumen Grade (%)	11.5	11.5
Bitumen Recovery (%)	90.0	90.0
Extraction Stream Factor	0.70	0.70
Ore Feed Rate - Plant (t/h)	6464	9234
- Train (t/h)	2155	3078
Number of Trains	3	3
Utilities Demands		
Steam (50 #) (t/h)	355	507
Hot Water (85°C) (m^3/h)	2586	3694
Electrical (MW)	30	43
Diluent (t/h)	470	671
Diluent Losses (t/h)	10	14

APPENDIX E

UPGRADING SCHEMES

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- 2.5 H-Oil Unit 17
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1.0 CASE REFERENCES

Included in this section are the upgrading block flow diagrams for the selected nine cases. A summary description of the upgrading schemes developed for each case can be found in Volume I, Section 4.3, Description of Selected Cases, of this report. The figure numbers and the location of the summary description in the text (Volume I), for each case, are as follows:

Case 1
Figure 1.0-1
Section 4.3.1.3

Case 2
Figure 1.0-2
Section 4.3.2.3

Case 3
Figure 1.0-3
Section 4.3.3.3

Case 4
Figure 1.0-4
Section 4.3.4.3

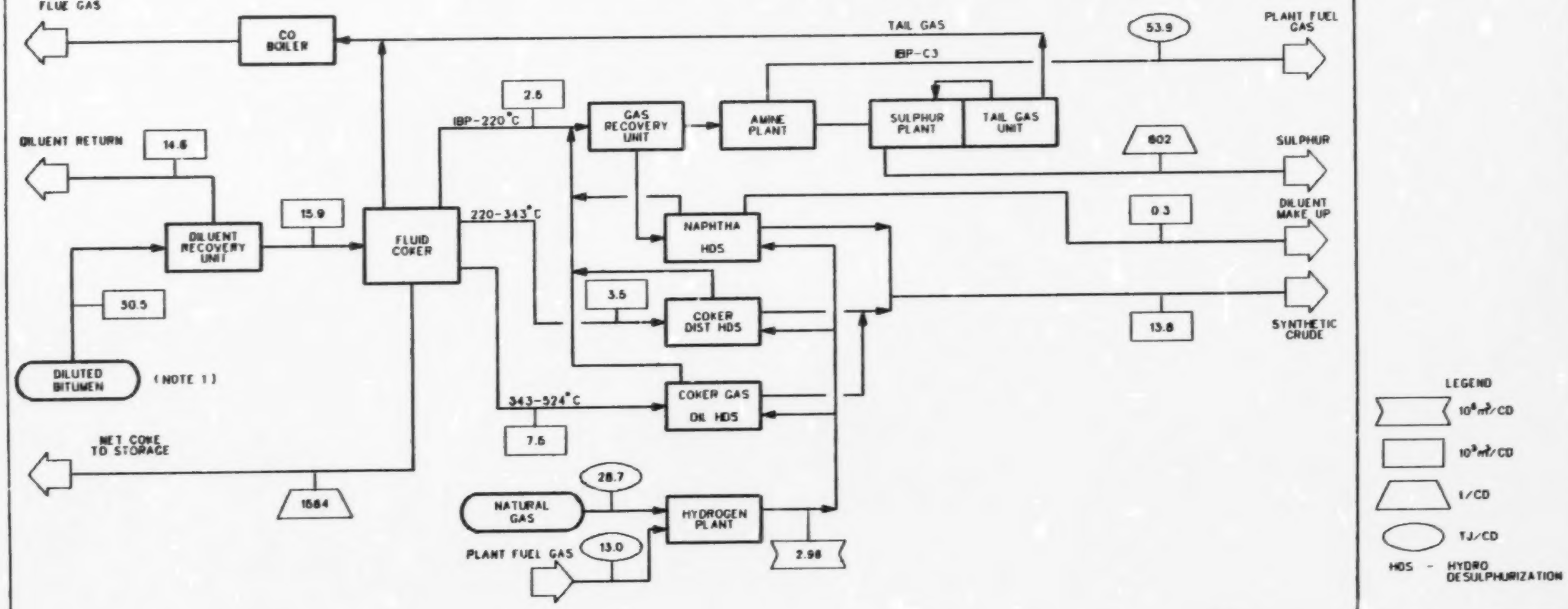
Case 5
Figures 1.0 - 5A and 1.0 - 5B
Section 4.3.5.3

Case 6
Figures 1.0 - 6A and 1.0 - 6B
Section 4.3.6.3

Case 7
Figure 1.0 - 7
Section 4.3.7.3

NOTES

(1) DILUTED BITUMEN IS ON A WATER FREE BASIS


FLUE GAS
CO BOILER
TAIL GAS
53.9
PLANT FUEL GAS
IBP-C3
DILUENT RETURN
14.6
2.6
IBP-220°C
GAS RECOVERY UNIT
AMINE PLANT
SULPHUR PLANT
TAIL GAS UNIT
602
SULPHUR
15.9
DILUENT RECOVERY UNIT
FLUID COKER
220-343°C
NAPHTHA HDS
0.3
DILUENT MAKE UP
30.5
3.5
COKER DIST HDS
SYNTHETIC CRUDE
13.8
DILUTED BITUMEN
(NOTE 1)
COKER GAS OIL HDS
343-524°C
NET COKE TO STORAGE
7.6
1584
28.7
NATURAL GAS
HYDROGEN PLANT
PLANT FUEL GAS
13.0
2.98
LEGEND
10⁶ m³/CD
10³ m³/CD
t/CD
TJ/CD
HDS - HYDRO DESULPHURIZATION

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
CASE 1 - UPGRADING
15.9k m³/CD (100,000 BPCD)
BITUMEN FEED TO
FLUID COKER

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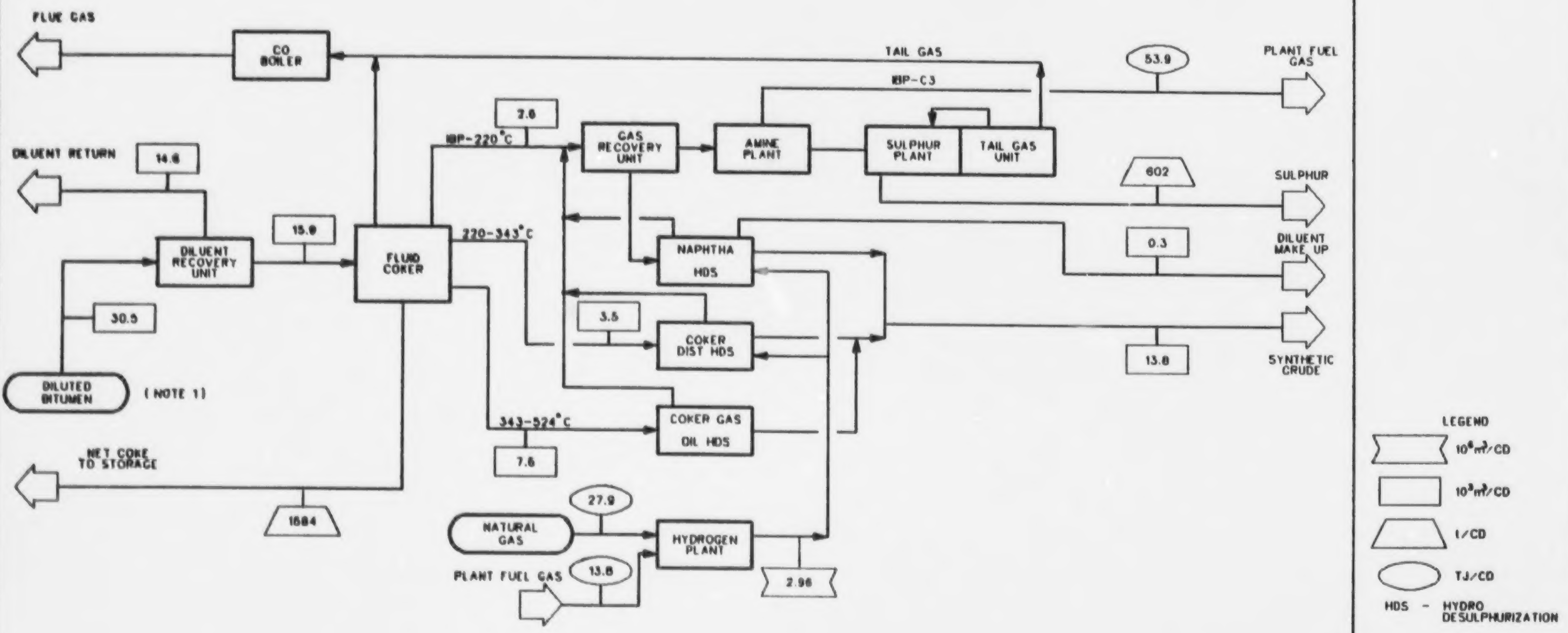
T.F.W.	G.F.L.	12/07/82	TM-500

DWG No. TS500501-REV 1

FIGURE 1.0-1

NOTES

(1) DILUTED BITUMEN IS ON A WATER FREE BASIS


FLUE GAS
CO BOILER
TAIL GAS
IBP-C3
53.9
PLANT FUEL GAS
DILUENT RETURN
14.6
2.6
IBP-220°C
GAS RECOVERY UNIT
AMINE PLANT
SULPHUR PLANT
TAIL GAS UNIT
602
SULPHUR
15.9
DILUENT RECOVERY UNIT
FLUID COKER
220-343°C
NAPHTHA HDS
0.3
DILUENT MAKE UP
30.5
3.5
COKER DIST HDS
13.8
SYNTHETIC CRUDE
DILUTED BITUMEN
(NOTE 1)
343-524°C
COKER GAS OIL HDS
NET COKE TO STORAGE
7.6
1684
27.9
NATURAL GAS
HYDROGEN PLANT
PLANT FUEL GAS
13.8
2.96
LEGEND
10⁶m³/CD
10³m³/CD
t/CD
TJ/CD
HDS - HYDRO DESULPHURIZATION

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

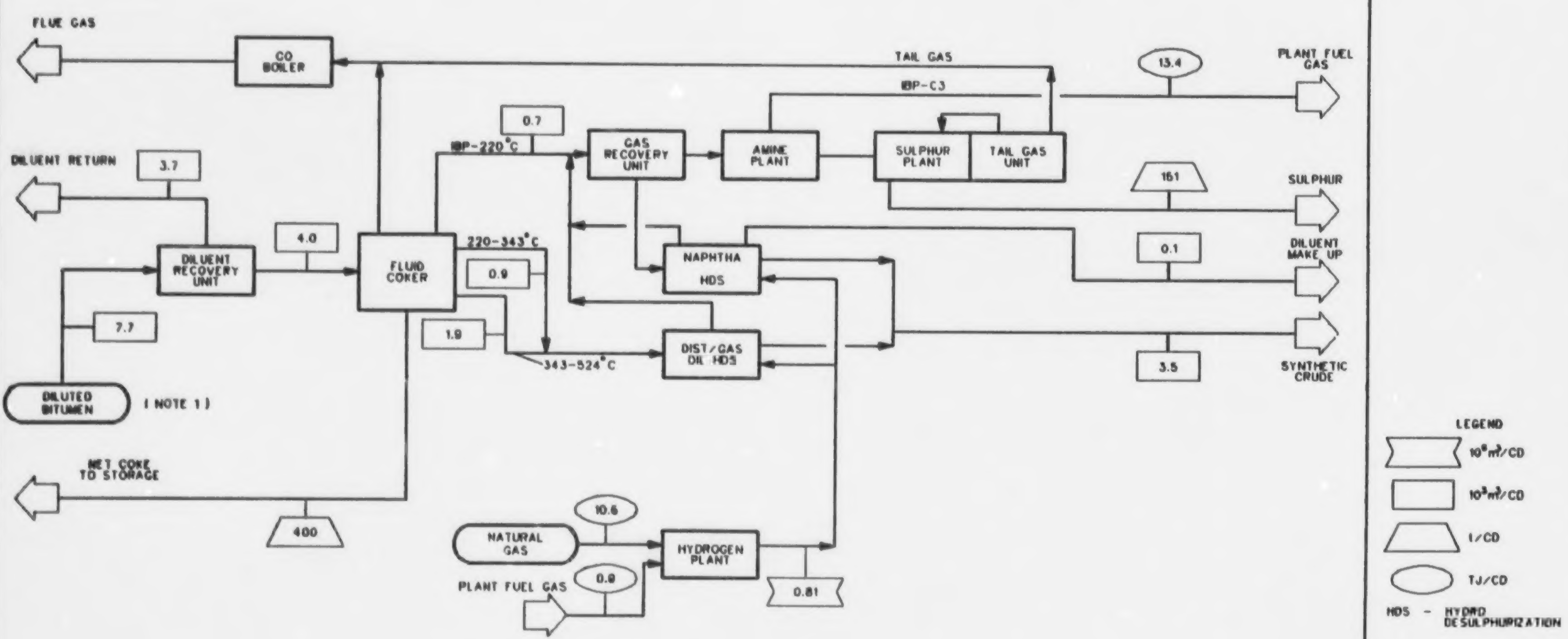
PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
CASE 2 - UPGRADING
15.9k m³/CD (100,000 BPCD)
BITUMEN FEED TO
FLUID COKER

DRAWN BY: T.F.W.	CHECKED BY: G.F.L.	DATE: 12/08/82	PROJECT No: TM-500
TECHMAN		DWG. No. TS500502-REV. 1	
		FIGURE 1.0-2	

NOTES

(1) DILUTED BITUMEN IS ON A WATER FREE BASIS


FLUE GAS
CO BOILER
TAIL GAS
IBP-C3
13.4
PLANT FUEL GAS
DILUENT RETURN
3.7
0.7
IBP-220°C
GAS RECOVERY UNIT
AMINE PLANT
SULPHUR PLANT
TAIL GAS UNIT
151
SULPHUR
4.0
DILUENT RECOVERY UNIT
FLUID COKER
220-343°C
0.9
NAPHTHA HDS
0.1
DILUENT MAKE UP
7.7
1.9
343-524°C
DIST/GAS OIL HDS
3.5
SYNTHETIC CRUDE
DILUTED BITUMEN
(NOTE 1)
NET COKE TO STORAGE
400
10.6
NATURAL GAS
HYDROGEN PLANT
PLANT FUEL GAS
0.9
0.81
LEGEND
$10^6 m^3/CD$
$10^3 m^3/CD$
t/CD
TJ/CD
HDS - HYDRO DESULPHURIZATION

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

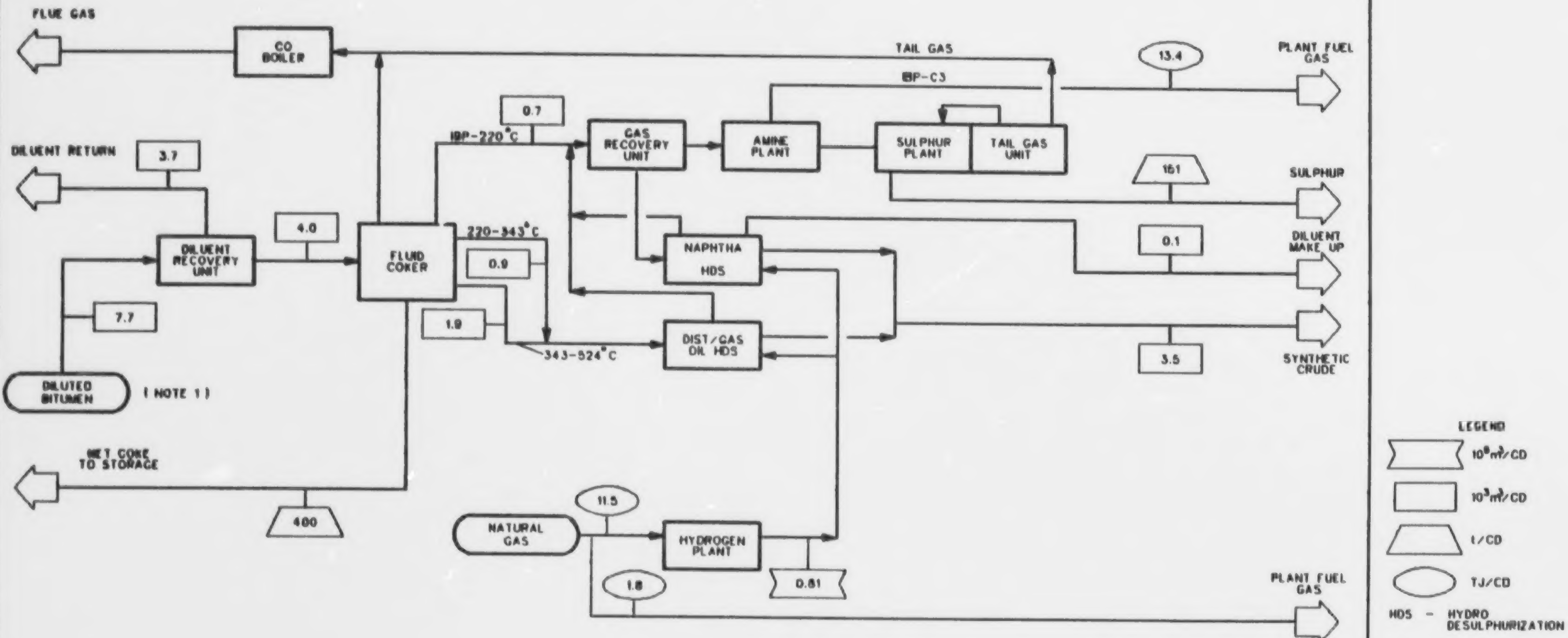
PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
CASE 3 - UPGRADING
4k m^3/CD (25,000 BPCD)
BITUMEN FEED TO
FLUID COKER

DRAWN BY: T.F.W.	CHECKED BY: G.F.L.	DATE: 12/08/82	PROJECT No: TM-500
TECHMAN		DWG No: TS500503-REV. 1	
		FIGURE 1.0-3	

NOTES

(1) DILUTED BITUMEN IS ON A WATER FREE BASIS



FLUE GAS
CO BOILER
TAIL GAS
13.4
PLANT FUEL GAS
IBP-C3
0.7
IBP-220°C
GAS RECOVERY UNIT
AMINE PLANT
SULPHUR PLANT
TAIL GAS UNIT
DILUENT RETURN
3.7
161
SULPHUR
DILUENT RECOVERY UNIT
4.0
FLUID COKER
220-343°C
0.9
NAPHTHA HDS
0.1
DILUENT MAKE UP
7.7
1.9
DIST/GAS OIL HDS
343-524°C
3.5
SYNTHETIC CRUDE
DILUTED BITUMEN
(NOTE 1)
NET COKE TO STORAGE
400
NATURAL GAS
11.5
HYDROGEN PLANT
1.8
0.81
PLANT FUEL GAS
LEGEND
10⁶m³/CD
10³m³/CD
t/CD
TJ/CD
HDS - HYDRO DESULPHURIZATION

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

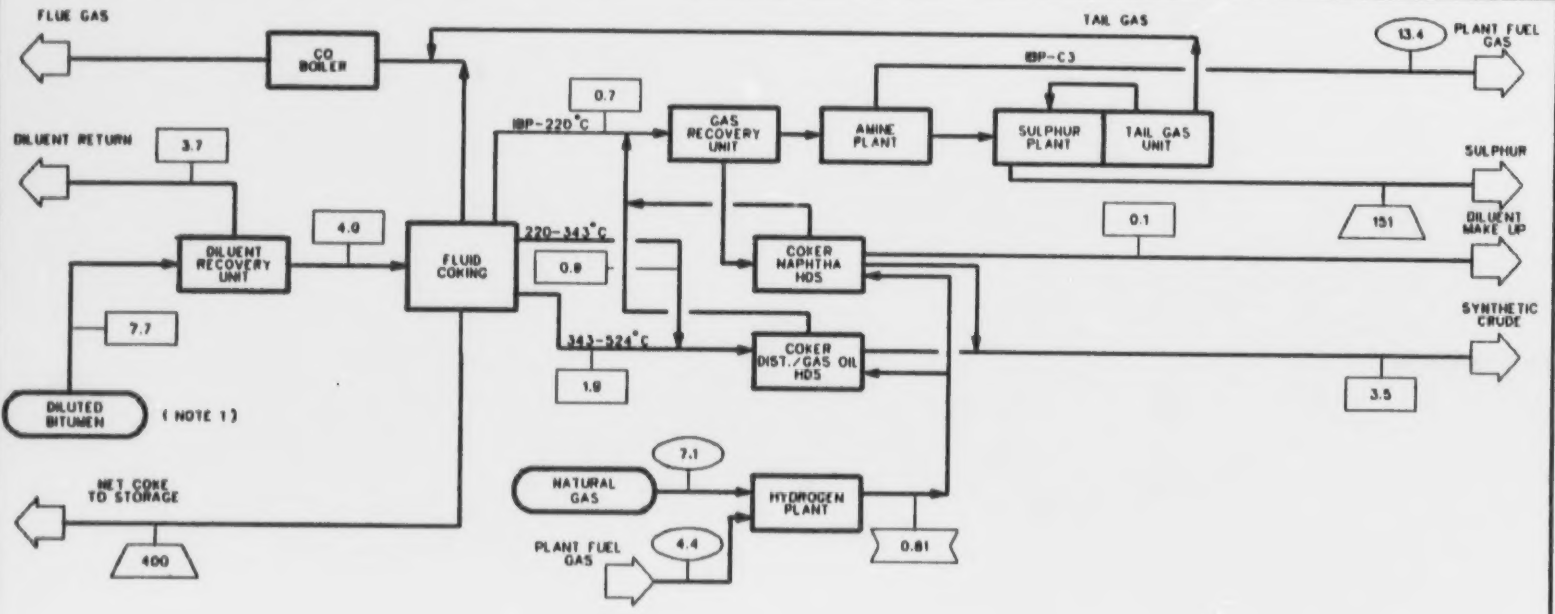
DRAWING TITLE:
CASE 4 - UPGRADING
4k m³/CD (25,000 BPCD)
BITUMEN FEED TO
FLUID COKER

DRAWN BY:	CHECKED BY:	DATE:	PROJECT No:
T.F.W.	G.F.L.	12/08/82	TM-500

TECHMAN

DWG No: TS500504-REV. 1

FIGURE 10-4


FLUE GAS
CO BOILER
TAIL GAS
13.4
PLANT FUEL GAS
IBP-C3
0.7
IBP-220°C
GAS RECOVERY UNIT
AMINE PLANT
SULPHUR PLANT
TAIL GAS UNIT
DILUENT RETURN
3.7
SULPHUR
151
4.0
DILUENT RECOVERY UNIT
FLUID COKING
220-343°C
0.9
COKER NAPHTHA HDS
0.1
DILUENT MAKE UP
7.7
343-524°C
COKER DIST./GAS OIL HDS
SYNTHETIC CRUDE
1.9
3.5
DILUTED BITUMEN
(NOTE 1)
NET COKE TO STORAGE
400
7.1
NATURAL GAS
HYDROGEN PLANT
PLANT FUEL GAS
4.4
0.81

NOTES

(1) DILUTED BITUMEN IS ON A WATER FREE BASIS

LEGEND

⋈	10^6 m³/CD
▭	10^3 m³/CD
⏢	t/CD
⬭	TJ/CD
HDS	HYDRO DE-SULPHURIZATION

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

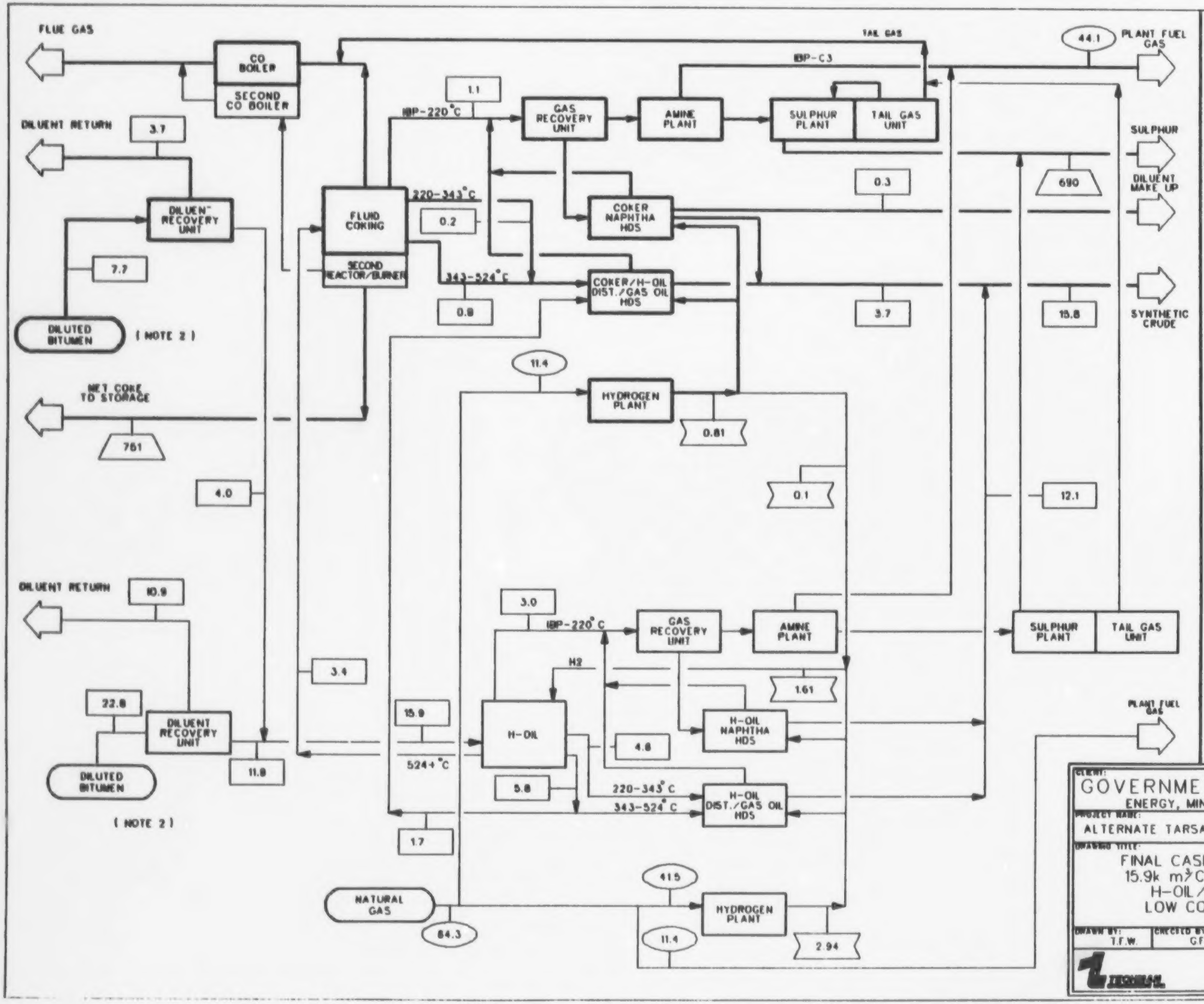
PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
INITIAL CASE 5 - UPGRADING
4k m³/CD (25,000 BPCD)
FLUID COKING

DRAWN BY:	CHECKED BY:	DATE:	PROJECT No.:
T.F.W.	G.F.L.	12/08/82	TM-500

DWG No. TS500505A-REV. 1

FIGURE 1.0-5A


FLUE GAS
CO BOILER
SECOND CO BOILER
DILUENT RETURN
3.7
DILUENT RECOVERY UNIT
7.7
DILUTED BITUMEN
(NOTE 2)
NET COKE TO STORAGE
761
4.0
FLUID COKING
SECOND REACTOR/BURNER
IBP-220°C
1.1
220-343°C
0.2
343-524°C
0.8
GAS RECOVERY UNIT
AMINE PLANT
SULPHUR PLANT
TAIL GAS UNIT
TAIL GAS
IBP-C3
COKER NAPHTHA HDS
COKER/H-OIL DIST./GAS OIL HDS
11.4
HYDROGEN PLANT
0.81
0.3
3.7
690
15.8
44.1
PLANT FUEL GAS
SULPHUR
DILUENT MAKE UP
SYNTHETIC CRUDE
0.1
12.1
DILUENT RETURN
10.9
22.8
DILUENT RECOVERY UNIT
11.8
DILUTED BITUMEN
(NOTE 2)
3.4
15.9
524+°C
1.7
H-OIL
3.0
IBP-220°C
H2
5.8
4.8
220-343°C
343-524°C
GAS RECOVERY UNIT
AMINE PLANT
1.61
H-OIL NAPHTHA HDS
H-OIL DIST./GAS OIL HDS
SULPHUR PLANT
TAIL GAS UNIT
PLANT FUEL GAS
NATURAL GAS
84.3
41.5
11.4
HYDROGEN PLANT
2.94

NOTES

(1) ——— STAGE 1 PROCESS EQUIP. FOR 4k m³/CD (25,000 BPCD) CAPACITY AND REUSED FOR STAGE 2

——— STAGE 2 PROCESS EQUIP. FOR 15.9k m³/CD (100,000 BPCD) CAPACITY

(2) DILUTED BITUMEN IS ON A WATER FREE BASIS

LEGEND

$10^6 m^3/CD$

$10^3 m^3/CD$

t/CD

TJ/CD

HDS HYDRO DE-SULPHURIZATION

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

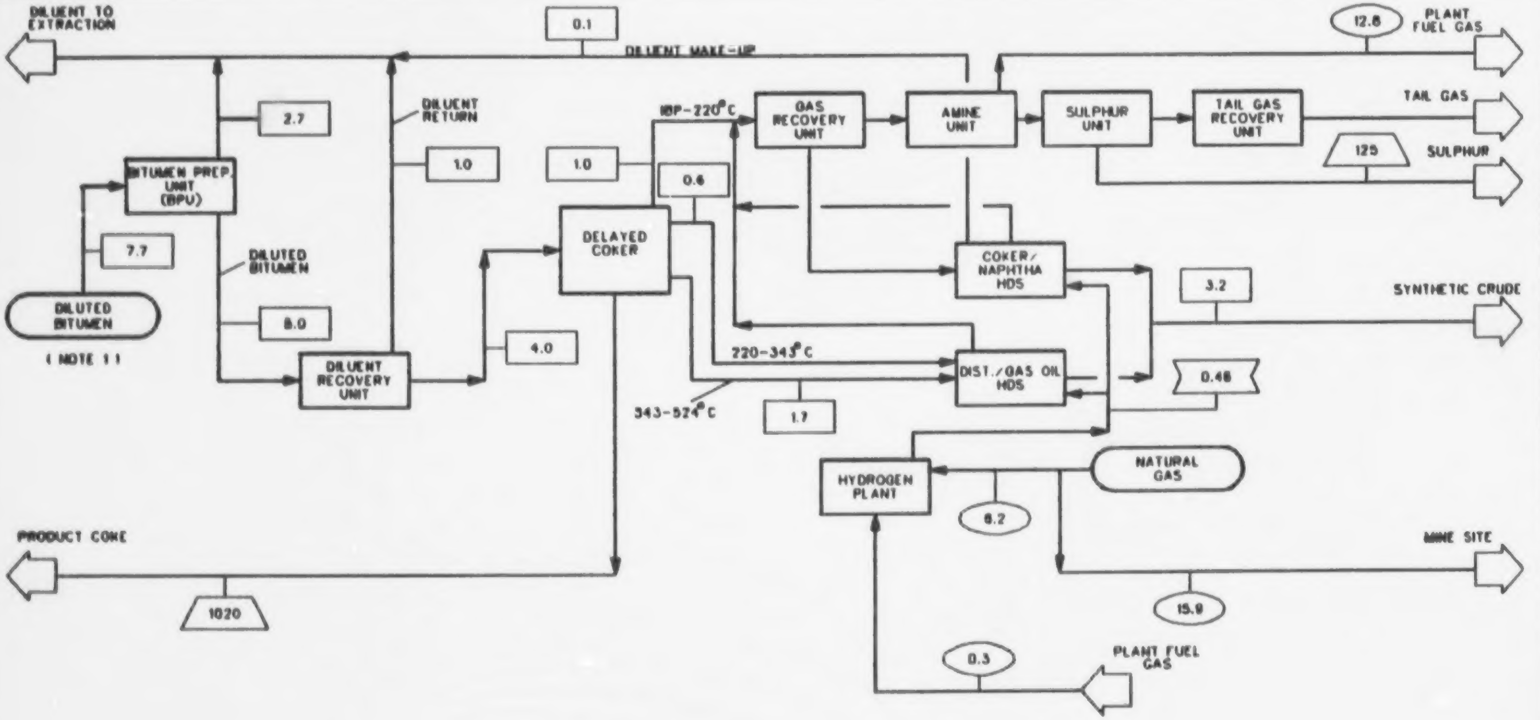
PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
FINAL CASE 5 - UPGRADING
15.9k m³/CD (100,000 BPCD)
H-OIL/FLUID COKING
LOW CONVERSION 60%

DRAWN BY:	CHECKED BY:	DATE:	PROJECT No.:
T.F.W.	G.F.L.	12/08/82	TM-500

DWG. No.: TS500505B-REV. 1

FIGURE 10-5B


DILUENT TO EXTRACTION
0.1
DILUENT MAKE-UP
12.8
PLANT FUEL GAS
2.7
DILUENT RETURN
1.0
IBP-220°C
GAS RECOVERY UNIT
AMINE UNIT
SULPHUR UNIT
TAIL GAS RECOVERY UNIT
TAIL GAS
125
SULPHUR
BITUMEN PREP. UNIT (BPU)
1.0
0.6
7.7
DELAYED COKER
COKER/ NAPHTHA HDS
3.2
SYNTHETIC CRUDE
DILUTED BITUMEN
DILUTED BITUMEN
(NOTE 1)
8.0
DILUENT RECOVERY UNIT
4.0
220-343°C
DIST./GAS OIL HDS
0.46
343-524°C
1.7
HYDROGEN PLANT
NATURAL GAS
6.2
PRODUCT COKE
MINE SITE
1020
15.9
0.3
PLANT FUEL GAS

NOTES:

(1) DILUTED BITUMEN IS ON A FREE WATER BASIS

LEGEND

$10^6 m^3/CD$

$10^3 m^3/CD$

t/CD

TJ/CD

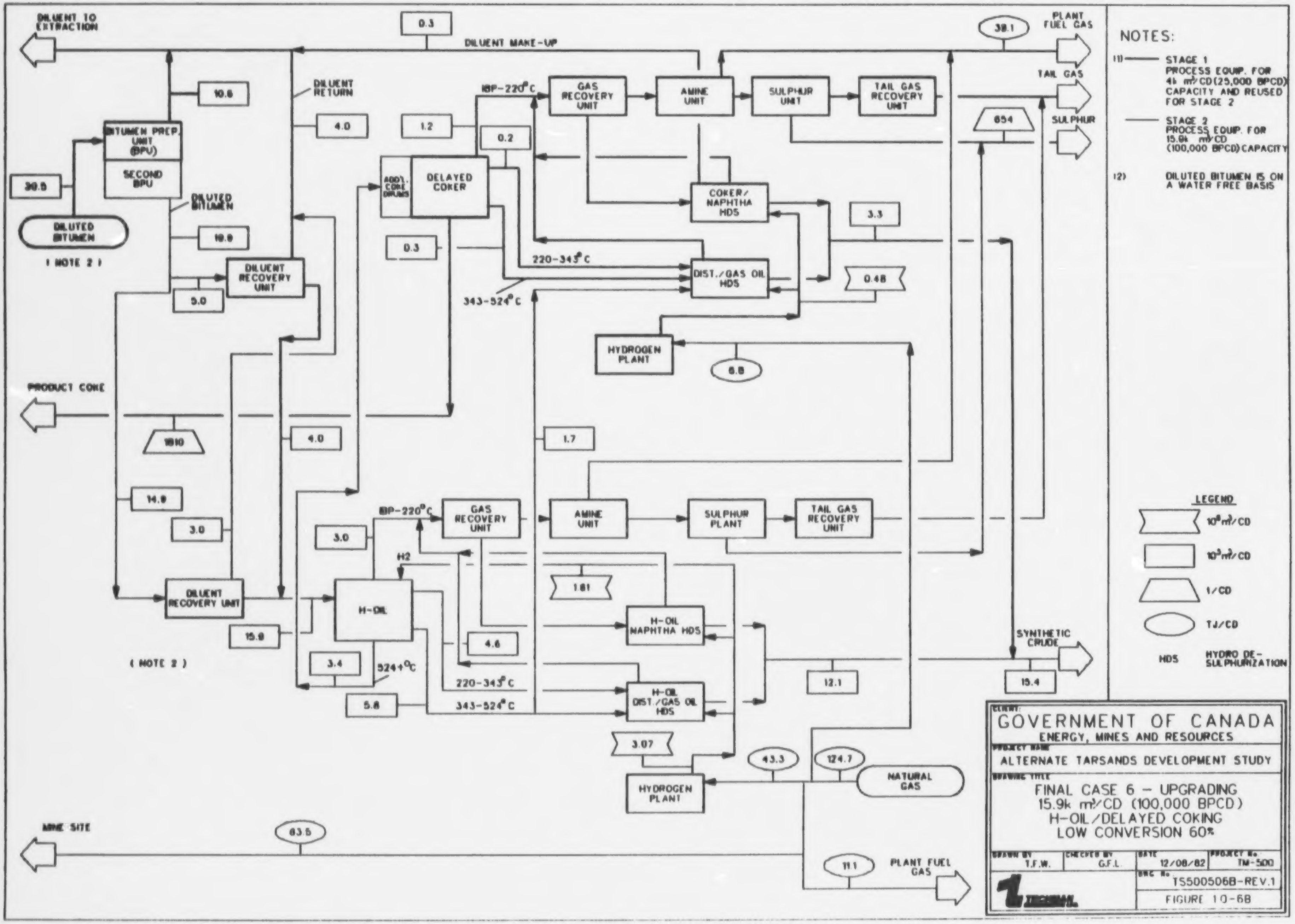
HDS HYDRO DE-SULPHURIZATION

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
INITIAL CASE 6 – UPGRADING
4k m^3/CD (25,000 BPCD)
DELAYED COKING

DRAWN BY	CHECKED BY	DATE	PROJECT No.
T.F.W.	GFL	12/08/82	TM-500
		DWG No.	TS500506A-REV 1
			FIGURE 1.0-6A


DILUENT TO EXTRACTION
0.3
DILUENT MAKE-UP
38.1
PLANT FUEL GAS
TAIL GAS
SULPHUR
654
10.6
DILUENT RETURN
4.0
BITUMEN PREP. UNIT (BPU)
SECOND BPU
30.5
DILUTED BITUMEN
DILUTED BITUMEN
(NOTE 2)
10.9
DILUENT RECOVERY UNIT
5.0
1.2
0.2
IBP-220°C
GAS RECOVERY UNIT
AMINE UNIT
SULPHUR UNIT
TAIL GAS RECOVERY UNIT
ADD'L COKE DRUMS
DELAYED COKER
COKER/ NAPHTHA HDS
3.3
0.3
220-343°C
343-524°C
DIST./GAS OIL HDS
0.48
HYDROGEN PLANT
6.8
PRODUCT COKE
1910
4.0
1.7
14.9
3.0
3.0
IBP-220°C
GAS RECOVERY UNIT
AMINE UNIT
SULPHUR PLANT
TAIL GAS RECOVERY UNIT
H2
1.81
DILUENT RECOVERY UNIT
H-OIL
15.9
4.6
H-OIL NAPHTHA HDS
(NOTE 2)
3.4
524+°C
220-343°C
343-524°C
5.8
H-OIL DIST./GAS OIL HDS
12.1
SYNTHETIC CRUDE
15.4
3.07
43.3
124.7
NATURAL GAS
HYDROGEN PLANT
MINE SITE
63.5
11.1
PLANT FUEL GAS
LEGEND
10⁶m³/CD
10³m³/CD
t/CD
TJ/CD
HDS
HYDRO DE-SULPHURIZATION

NOTES:

(1) —— STAGE 1 PROCESS EQUIP. FOR 4k m³/CD (25,000 BPCD) CAPACITY AND REUSED FOR STAGE 2

—— STAGE 2 PROCESS EQUIP. FOR 15.9k m³/CD (100,000 BPCD) CAPACITY

(2) DILUTED BITUMEN IS ON A WATER FREE BASIS

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
FINAL CASE 6 – UPGRADING
15.9k m³/CD (100,000 BPCD)
H-OIL/DELAYED COKING
LOW CONVERSION 60%

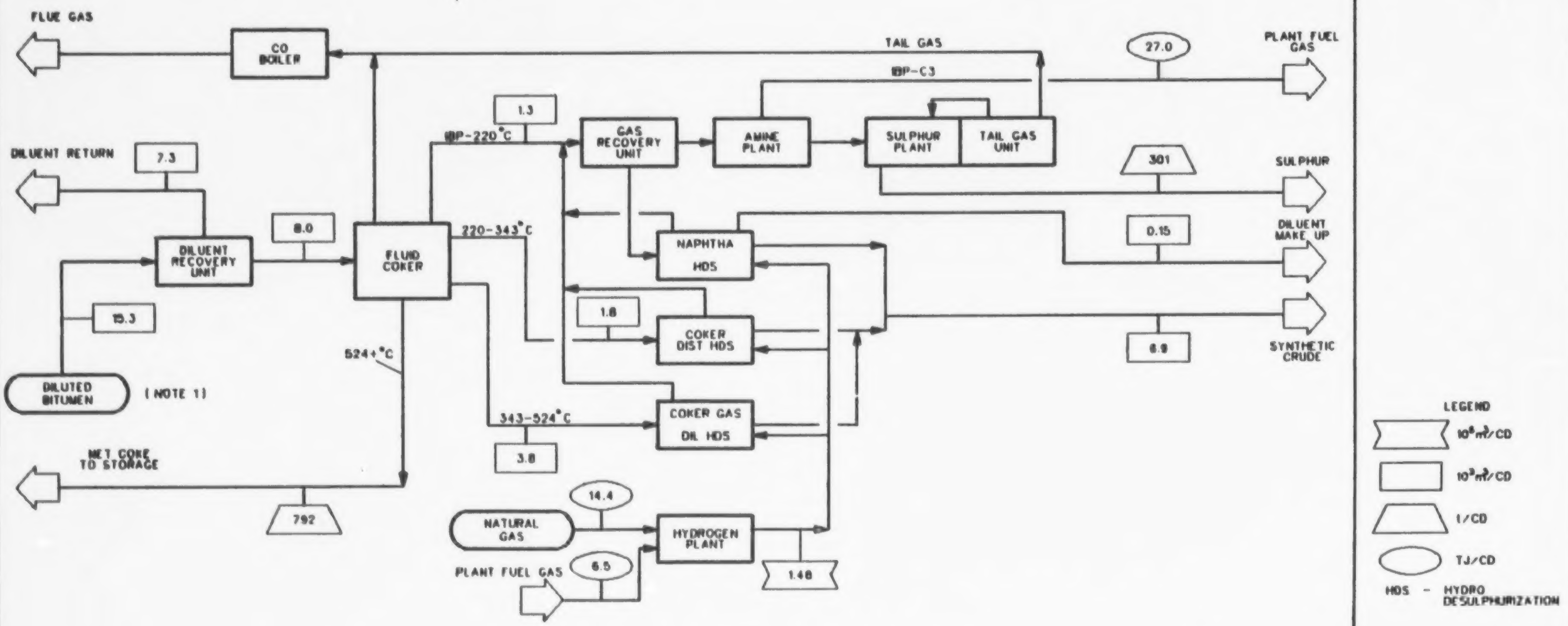
DRAWN BY	CHECKED BY	DATE	PROJECT No.
T.F.W.	G.F.L.	12/08/82	TM-500

DWG No. TS500506B-REV.1

FIGURE 10-6B

NOTES

1) DILUTED BITUMEN IS ON A WATER FREE BASIS

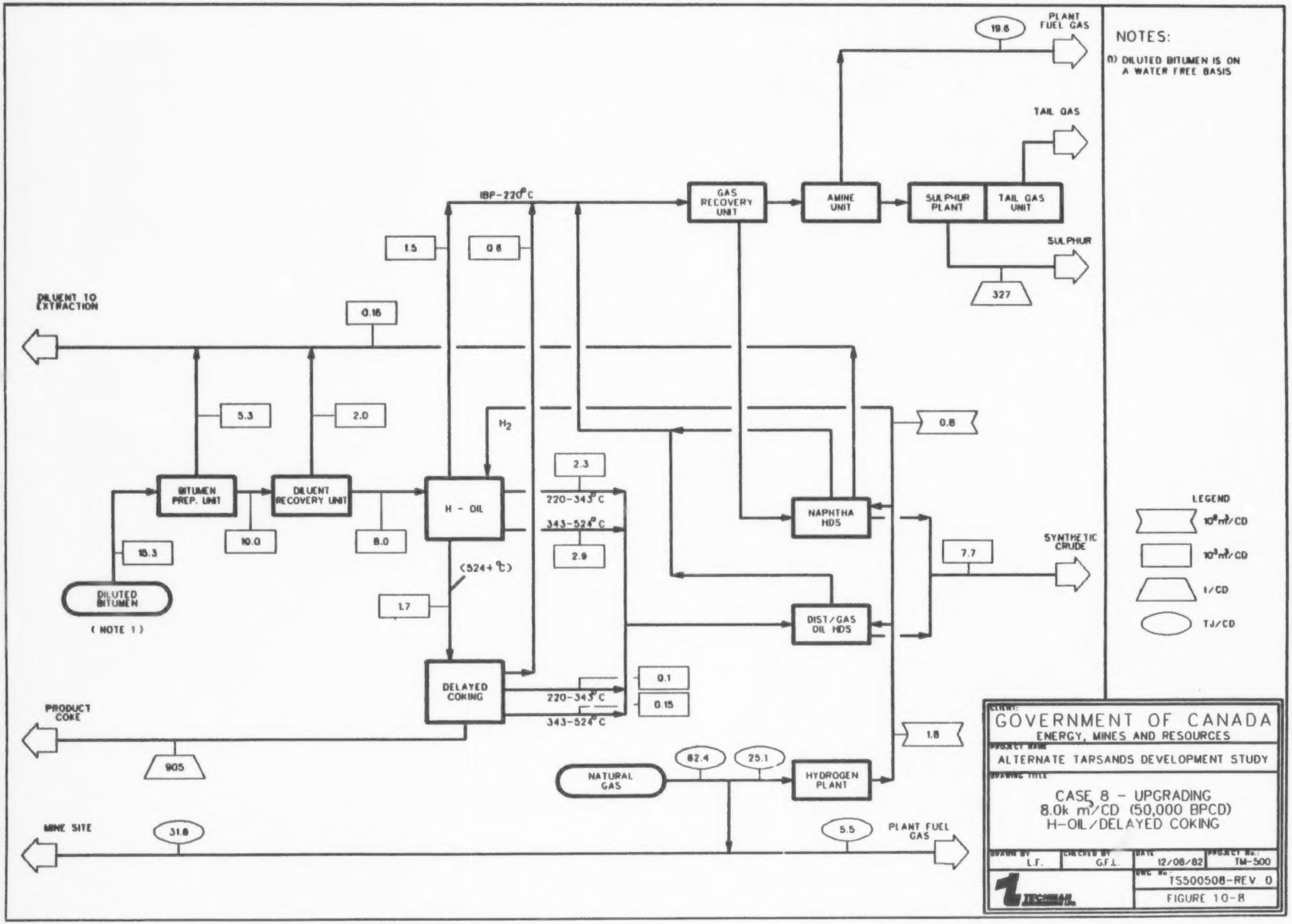

FLUE GAS
CO BOILER
TAIL GAS
PLANT FUEL GAS
27.0
IBP-C3
DILUENT RETURN
7.3
1.3
IBP-220°C
GAS RECOVERY UNIT
AMINE PLANT
SULPHUR PLANT
TAIL GAS UNIT
301
SULPHUR
8.0
DILUENT RECOVERY UNIT
FLUID COKER
220-343°C
NAPHTHA HDS
0.15
DILUENT MAKE UP
15.3
1.8
COKER DIST HDS
SYNTHETIC CRUDE
6.9
524+°C
DILUTED BITUMEN
(NOTE 1)
343-524°C
COKER GAS OIL HDS
3.8
NET COKE TO STORAGE
792
14.4
NATURAL GAS
HYDROGEN PLANT
PLANT FUEL GAS
6.5
1.48
LEGEND
10⁶ m³/CD
10³ m³/CD
t/CD
TJ/CD
HDS - HYDRO DESULPHURIZATION

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
CASE 7 - UPGRADING
8.0k m³/CD (50,000 BPCD)
BITUMEN FEED TO
FLUID COKER

DRAWN BY:	CHECKED BY:	DATE:	PROJECT No.:
T.F.W.	G.F.L.	12/08/82	TM-500
		DWG No.	TS500507-REV. 0
			FIGURE 1.0-7


DILUTED BITUMEN
(NOTE 1)
15.3
BITUMEN PREP. UNIT
10.0
5.3
DILUENT RECOVERY UNIT
8.0
2.0
DILUENT TO EXTRACTION
0.16
H - OIL
H2
1.5
0.8
IBP-220°C
(524+°C)
1.7
DELAYED COKING
2.3
220-343°C
343-524°C
2.9
220-343°C
343-524°C
0.1
0.15
PRODUCT COKE
905
GAS RECOVERY UNIT
AMINE UNIT
SULPHUR PLANT
TAIL GAS UNIT
19.6
PLANT FUEL GAS
TAIL GAS
SULPHUR
327
NAPHTHA HDS
DIST/GAS OIL HDS
0.8
7.7
SYNTHETIC CRUDE
1.8
HYDROGEN PLANT
NATURAL GAS
82.4
25.1
5.5
PLANT FUEL GAS
MINE SITE
31.8
LEGEND
10⁶m³/CD
10³m³/CD
t/CD
TJ/CD

NOTES:

1) DILUTED BITUMEN IS ON A WATER FREE BASIS

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

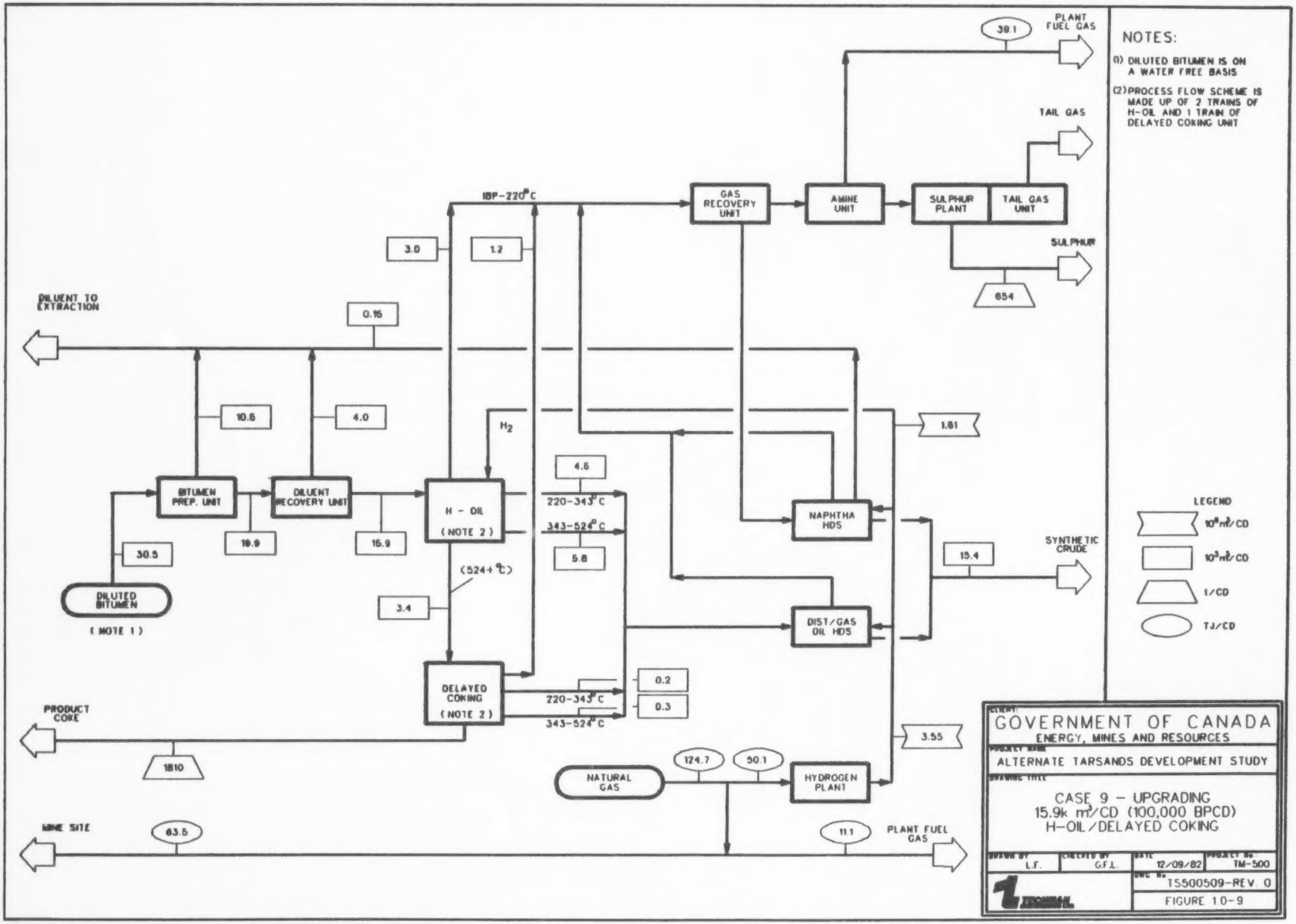
PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
CASE 8 - UPGRADING
8.0k m^3/CD (50,000 BPCD)
H-OIL/DELAYED COKING

DRAWN BY	CHECKED BY	DATE	PROJECT No.:
L.F.	G.F.L.	12/08/82	TM-500

DWG No.: TS500508-REV 0

FIGURE 10-8


DILUTED BITUMEN
(NOTE 1)
30.5
BITUMEN PREP. UNIT
10.6
19.9
DILUENT RECOVERY UNIT
4.0
15.9
DILUENT TO EXTRACTION
0.15
H - OIL
(NOTE 2)
H2
3.0
1.2
IBP-220°C
(524+°C)
3.4
DELAYED COKING
(NOTE 2)
220-343°C
343-524°C
4.6
5.8
0.2
0.3
PRODUCT COKE
1810
GAS RECOVERY UNIT
AMINE UNIT
SULPHUR PLANT
TAIL GAS UNIT
39.1
PLANT FUEL GAS
TAIL GAS
SULPHUR
654
NAPHTHA HDS
DIST/GAS OIL HDS
1.81
15.4
SYNTHETIC CRUDE
NATURAL GAS
124.7
50.1
HYDROGEN PLANT
3.55
MINE SITE
63.5
11.1
PLANT FUEL GAS

NOTES:

(1) DILUTED BITUMEN IS ON A WATER FREE BASIS

(2) PROCESS FLOW SCHEME IS MADE UP OF 2 TRAINS OF H-OIL AND 1 TRAIN OF DELAYED COKING UNIT

LEGEND

⧖	$10^6 m^3/CD$
▭	$10^3 m^3/CD$
⏢	t/CD
⬭	TJ/CD

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE
CASE 9 – UPGRADING
15.9k m^3/CD (100,000 BPCD)
H-OIL/DELAYED COKING

DESIGN BY	CHECKED BY	DATE	PROJECT No.
L.F.	G.F.L.	12/09/82	TM-500

DWG No. T5500509-REV. 0

FIGURE 10-9

Case 8

Figure 1.0-8
Section 4.3.8.3

Case 9

Figure 1.0-9
Section 4.3.9.3

Section 2.0 includes a short technical description of the process units involved in all the upgrading schemes. Some supplementary case descriptions are included with these unit descriptions.

2.0 UNIT DESCRIPTIONS

2.1 Diluent Recovery Unit (DRU)

The purpose of these facilities in Cases 1-5 and 7 is to produce a dry bitumen and recover the diluent from the mixture of diluent/bitumen/ water. The recovered diluent is returned to the Extraction Plant for reuse. After the diluent is removed, the hot bitumen is normally fed directly to the Delayed Coking or Fluid Coking Unit with nil energy conservation through bottoms/feed heat exchange.

The Diluent Recovery Unit consists of a series of steam heaters, a fired heater, a flash vessel and a fractionating tower. In all cases, the DRU accompanies the location of the upgrader. It follows then that in Cases 1-5 and 7 the DRU which is located adjacent to the mine site is fed from the Extraction Plant with 48 percent diluent in diluted bitumen.

In Cases 6, 8 and 9 the DRU is remote from the mine (i.e. in the Edmonton area) and the feed from the pipeline is 20 percent diluent in the diluted bitumen.

2.2 Bitumen Preparation Unit (BPU)

The Bitumen Preparation Unit is needed to prepare the diluted bitumen for pipelining to the remote upgrader in the Edmonton area. The BPU is therefore only needed in Cases 6, 8 and 9.

Diluted bitumen should contain a minimum of 20 percent diluent by volume for proper pipelining characteristics (110 c.s. viscosity at 10°C). The BPU therefore reduces the diluent content in the diluted bitumen from 48 percent by volume to 20 percent by volume.

The unit is physically similar to the Diluent Recovery Unit with the exception that heat recovery through bottoms/feed exchange is exercised. The utility requirements are, therefore, reduced.

2.3 Fluid Coking Unit

Fluid Coking is a carbon rejection thermal cracking process for upgrading heavy feedstocks into more valuable, lighter products. It is a Primary Upgrader currently used by several refiners to upgrade their heavier feedstocks such as pitch to fuel gas, naphtha, middle distillate and heavy gas oil.

Fluid cokers consist of a reaction section and a fractionation section in series. The reaction section is made up of two primary vessels:

- a scrubber-reactor; and
- a burner.

Bitumen feedstock from the Diluent Recovery Unit is fed to the reaction section. The subsequent coking or cracking reaction produces a wide range of hydrocarbon products plus coke. The cracked vapours are quenched in the scrubber located on top of the reactor where the condensed heavier hydrocarbons (524+°C) and the entrained coke are collected and returned to the reactor. The fractionation section separates the resulting vapour products from the scrubber into coker gas/naphtha, middle distillate and heavy gas oil fractions. The fractions are then sent to their respective hydrotreaters for further processing. The coke formed in the reactor is partially burned in the burner to provide sufficient heat for the endothermal cracking reaction in the reactor. The balance of the coke is withdrawn as a net coke product.

An integral part of the Fluid Coking Unit is the CO Boiler unit. This unit produces medium or high pressure steam from the fluid coker burner off-gases. The gases are combusted to convert all carbon monoxide (CO) to carbon dioxide (CO_2). The resulting hot gases then produce steam in a water-tube boiler. This unit is a significant producer of steam and, from an energy standpoint, fits well with the Clark Hot Water Extraction process.

Fluid Coking was developed and licensed by Exxon Research and Engineering Co. and at present it is utilized by Syncrude Canada Ltd. on Athabasca bitumen at their Mildred Lake operation.

In this study, Fluid Coking was chosen for the Base Case (Case 1) because of its proven track record with Syncrude Canada Ltd. It was also chosen for Cases 2-5 and 7 where the Primary Upgrader is located adjacent to the mine site. Flue gas from the Fluid Coker is burned in the CO Boiler which in turn supplies considerable steam to the Upgrader and the Extraction Plant.

The synthetic crude oil yields from the Fluid Coker upgrader in Case 1 are about eight percent higher than a Delayed Coker of similar size, but 15 percent lower than the H-Oil/Fluid Coking processing scheme of Case 5 - Final.

2.4 Delayed Coking Unit

Delayed Coking is a carbon rejection thermal cracking process used in the industry to upgrade heavy feed stock to more valuable lighter hydrocarbons (e.g., pitch feeds from conventional crude oil and bitumen).

Delayed Coking consists of a reactor section (coke drums and heater) and a fractionation section. The Diluent Recovery Unit supplies bitumen to the reaction section of the Delayed Coker, where the bitumen is cracked into lighter material and coke. The coke is deposited in the drums and is essentially all carbon. It contains a significant proportion of the bitumen feed sulphur (31 percent) and virtually all of the metals in the feed. The lighter vapours are taken to the fractionation section where they are separated into coker gas/naphtha, middle distillate and heavy gas oil fractions. Each of the fractions is then charged to its appropriate Hydro Desulphurizer (HDS unit).

Delayed Coking is an old established and non-licensed process. It is currently used by Suncor Inc., Oil Sands Division at Fort McMurray as their Primary Upgrader.

In this study, Delayed Coking was considered for Cases 6, 8 and 9 where the upgrader is remote to the mine (i.e. the Edmonton area). Delayed Coking has a lower synthetic crude oil yield than Fluid Coking and the H-Oil/Fluid Coking combination. The lower liquid yield results in a higher coke production. The Delayed Coker service factor was set identically to all other primary upgraders, that is, 85 percent.

2.5 H-Oil Unit

H-Oil is a catalytic hydrocracking process licensed by Hydrocarbon Research Inc. (HRI). HRI have processed Athabasca bitumen in their demonstration unit, but have not built commercial units on Athabasca bitumen feed, as yet. For the purposes of this study, a 60 percent conversion rate on the 524+°C fraction of bitumen feed was chosen because H-Oil has been commercially demonstrated at this conversion rate on heavy refinery feedstocks.

Th H-Oil process converts heavy hydrocarbons to lighter more valuable products, plus residuum through the addition of hydrogen at elevated pressures and moderate temperatures (typically 8600 kPa and 460°C) and over a moving catalyst bed. Hydrogen and hydrocarbon feed are heated and fed upflow into an expanded (ebullated) catalyst bed. The ebullating bed feature, along with the ability to add and withdraw catalyst continuously to maintain activity, makes this design amenable to tarsands bitumen with its high ash, metals and solids content.

Residuum free liquid yields from the H-Oil unit proper are slightly less than those from Fluid Coking when both are compared on bitumen feed. However, when the H-Oil residuum is converted to lighter products in a small Fluid Coker, the Primary Upgrader yields are increased over straight Fluid Coking of bitumen by about 15 percent. This, of course, is done at the expense of less fluid coke production and a bigger hydrogen plant.

Maximum feedrate to one H-Oil reactor is about 6.4k m^3/SD (40,000 BPSD) as advised by HRI. With an assumed service factor of 0.85, this translates to four reactors in two trains for processing 15.9k m^3/CD (100,000 BPCD) of bitumen.

It should be noted that H-Oil residuum may have an increased coking tendency as opposed to bitumen feed when processed in a coking unit. This was allowed for in the design of Cases 5 and 6.

Although the H-Oil Process was selected as the hydrogen addition process for purposes of design and development of estimating data, there are other similar processes, such as L-C Fining, which may be equally satisfactory. The selection of H-Oil is primarily for convenience and should not be construed as an optimized selection.

2.6 Hydro Desulphurization Units (HDS Units)

Hydro Desulphurization, or Hydrotreating, is a catalytic reaction of hydrogen with the various petroleum fractions to:

- saturate olefins and di-olefins;
- partially desulphurize;
- partially denitrify; and
- deoxygenate the petroleum fractions.

This process is needed to saturate and improve the quality of the petroleum fractions so that a downstream oil refiner can easily process the fractions into finished marketable products.

HDS is a licensed process from such firms as Exxon, Shell Oil and Universal Oil Products (UOP). Each HDS unit consists of a reaction section and a fractionation section in series. The reaction section is typically made up of one to three fixed bed reactors where hydrogen and hydrocarbons are reacted. Although operating conditions vary with each feed, typical conditions are 7000 kPa and 390°C. The fractionation section removes any light material from the desired product and recycles it to the appropriate hydrotreaters.

The number of HDS units in any one train is a function of the desired product quality from the feeds. In Cases 1 and 2, three HDS units are provided - naphtha, distillate and gas oil - to produce a slightly superior synthetic crude oil quality, especially in the gas oil boiling range. In all other cases, the distillate is combined with the gas oil and fed to one HDS unit. As a result, the gas oil is higher in nitrogen content, when compared to the previous scheme, but is still acceptable as feed to a conventional oil refinery.

In our study, the degree of difficulty in hydro desulphurizing Primary Upgrader products starts with H-Oil products, increases with Delayed Coking products and is hardest with Fluid Coking products. Service factors for all HDS units followed the primary upgrader service factor of 85 percent.

2.7 Hydrogen Plant

High purity hydrogen (96+ mole percent) is required for the Hydro Desulphurization (HDS) reactions and the H-Oil hydrocracking reactions. Steam-Methane Reforming (SMR) is the chosen process for hydrogen production because of its demonstrated reliability in the oil and petrochemical industries.

In all cases studied, imported natural gas was the priority feed to the SMR because of its greater suitability (primarily methane). Where required, plant fuel gas supplemented the fuel portion of the hydrogen plant requirements.

Steam-methane reforming consists of four main steps:

- o Reforming in which methane is reacted with steam at elevated temperatures (760-825°C) over a nickel oxide catalyst to produce carbon monoxide (CO) and hydrogen. The reactor is a modified fired heater with catalyst filled tubes;

- o CO shift is a reaction whereby the CO produced in the first step is reacted with steam to produce carbon dioxide (CO_2) and more hydrogen. This reaction takes place over a fixed catalyst bed of chromium and iron oxide, at moderate temperatures (350°C);

- o Amine Treating contacts the product gas from the second step in an absorber to remove most of the CO_2;

- o Methanation reacts the remaining carbon oxides (CO and CO_2) in the product gas from the third step with hydrogen to produce methane and steam. The reaction is conducted in a fixed bed reactor of nickel catalyst at moderate temperatures (380-435°C). Removal of carbon oxides is mandatory to maintain HDS catalyst integrity.

2.8 Gas Recovery Unit (GRU)

The purpose of the Gas Recovery Unit is to produce:

- a propane and lighter stream which is subsequently sweetened in the Amine Plant and used for plant fuel gas;

- a butane stream which after treatment has the option of supplementing plant fuel, if needed, or of being blended in the synthetic crude oil product; and

- a pentanes plus stream (a light naphtha stream) which is subsequently hydrotreated in the naphtha HDS and becomes the light naphtha component of the synthetic crude.

The GRU is basically comprised then of a debutanizing section and a depropanizing section. No petrochemical feedstock, such as olefins, are recovered but the option does exist to recovery LPG in the future through the addition of a de-ethanizing section.

Feeds to the GRU originate from the Primary Upgraders (i.e. the Cokers and the H-Oil units) and from the mild cracking reactions in the HDS units.

A number of process options exist to effect the objectives of the GRU. For example, a sponge oil absorber could be used to recover the propane and heavier hydrocarbons, thereby eliminating the proposed depropanizer. The various options do not significantly impact on capital costs and are therefore left for Stage II of the study.

2.9 Amine Plant

Amine is a liquid that selectively absorbs hydrogen sulphide and partially co-absorbs carbon dioxide, depending on the amine type, from gaseous and liquid hydrocarbon streams. With proper selection of amine, the plant fuel gas hydrogen sulphide concentration can be reduced to a few ppm. Amine absorption is the widely used process in industry for sweetening plant gas and natural gas.

The Amine Plant consists of an absorption, or contacting, section and a regeneration section. The regeneration section strips the rich amine of hydrogen sulphide plus some carbon dioxide in a trayed column, with the resulting hydrogen sulphide rich stream fed to the Claus Sulphur Plant for conversion and recovery of the produced sulphur.

2.10 Sulphur Plant/Tail Gas Unit

Sulphur recovery with the Claus process is widely practised and accepted in the industry. A three reactor Claus Sulphur Unit with an overall recovery efficiency of 96 percent was assumed for all case studies. Service factors of about 75 percent were typically built into the Claus Unit design capacities. The Claus Unit receives its feed primarily as hydrogen sulphide (with some CO_2) from the amine regeneration units.

The Tail Gas Unit assumed for this study is the Shell Claus Off-Gas Treating (SCOT) unit. The SCOT process is also well known and accepted in the industry. The process basically converts any sulphur compounds in the Claus tail gas into hydrogen sulphide with the aid of a cobalt/molybdenum catalyst and hydrogen. The gas containing the hydrogen sulphide is then amine scrubbed for hydrogen sulphide recovery. Tail gas leaving the SCOT amine scrubber is incinerated at the unit, or in the CO Boiler when available, and typically contains 300 ppm by weight sulphur dioxide as it leaves the plant.

The sulphur recovery efficiency of the combined Sulphur Plant/Tail Gas Unit is 99+ percent. This recovery efficiency is based on feed gas to the Claus Unit, and does not account for other sulphur emissions such as from the Fluid Coker flue gas.

APPENDIX F

UTILITIES

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1.0 CASE 1

1.1 Description

A tarsand complex has unique utility requirements. It needs a large quantity of steam and electricity as well as hot water for the extraction process. Demand for steam and electricity fluctuates greatly, independent of each other. The Utility Plant must be able to satisfy the varying utility demands under all operating modes, including emergency and upset conditions.

The features of the Utility Plant for this case includes gas turbine generators in combined cycle with heat recovery boilers, back pressure turbine-generators, condensing/extraction turbine-generators, a boiler feed water system, a compressed air system, a water treatment plant, a substation and required ancillaries.

Under normal conditions, upgrading generates excess steam after internal consumption and for use in Offplots. This excess high pressure steam from the CO boilers, together with the high pressure steam generated in the heat recovery boilers, is used to generate electricity from the back pressure turbine-generators and condensing/extraction turbine-generators.

The load on the back pressure turbine-generators is fixed by the quantity of low pressure exhaust steam which is exported to the Extraction Plant.

The load on the condensing/extraction turbine-generator is determined from either the requirements of spinning reserve or loads in excess of what gas turbine and back pressure turbine-generators can carry. The condensing/extraction turbines will also generate low pressure steam up to about 85 percent of the rated load under extraction modes. The remaining load is carried by the gas turbine-generators.

Energy required to heat hot water for the extraction process is normally supplied from the low grade waste heat generated by upgrading. When an upgrading train is down or upset conditions in upgrading occur, part of the required heat is supplied by the low pressure steam generated by the back pressure turbines. Load demands on the back pressure turbines are greatest under these conditions and the capacity of the back pressure turbine-generators are selected to meet these conditions.

The boilers are also sized to meet the demands under these operating modes, with one boiler out of service.

The greatest demand for electricity occurs when the mining electrical load is at peak with all other plants running at their full design capacity. The gas turbine and condensing/extraction turbine generators are sized to meet this demand with approximately 90 percent loading.

The total installed generating capacity is such that in-plant capacity approximately matches the peak demand with the largest generator out of service.

A tie to Alberta Interconnected Systems (AIS) is provided as back-up power and partially to absorb any swings generated by the dragline operation.

As a large quantity of steam is directly used as live steam in the process areas and there are possibilities of the steam system being contaminated with hydrocarbon in the process streams, a large water treatment system to make up the lost steam is required.

The water treatment system consists of pretreatment which includes clarifiers, sandfilters, and demineralizers.

1.2 Equipment (Figure 1.2-1)

- Heat recovery boilers (3):
  330 t/h steam generating capacity
  at 6200 kpag and 482°C

- Gas turbine-generators (3):
  33 MW capacity

- Back pressure turbine-generators (2):
  50 MW capacity
  w/6200 kpag inlet and 350 kpag exhaust

- Condensing/extraction turbine-generators (2):
  30 MW capacity
  w/6200 kpag inlet and 7 kpa (absolute) exhaust

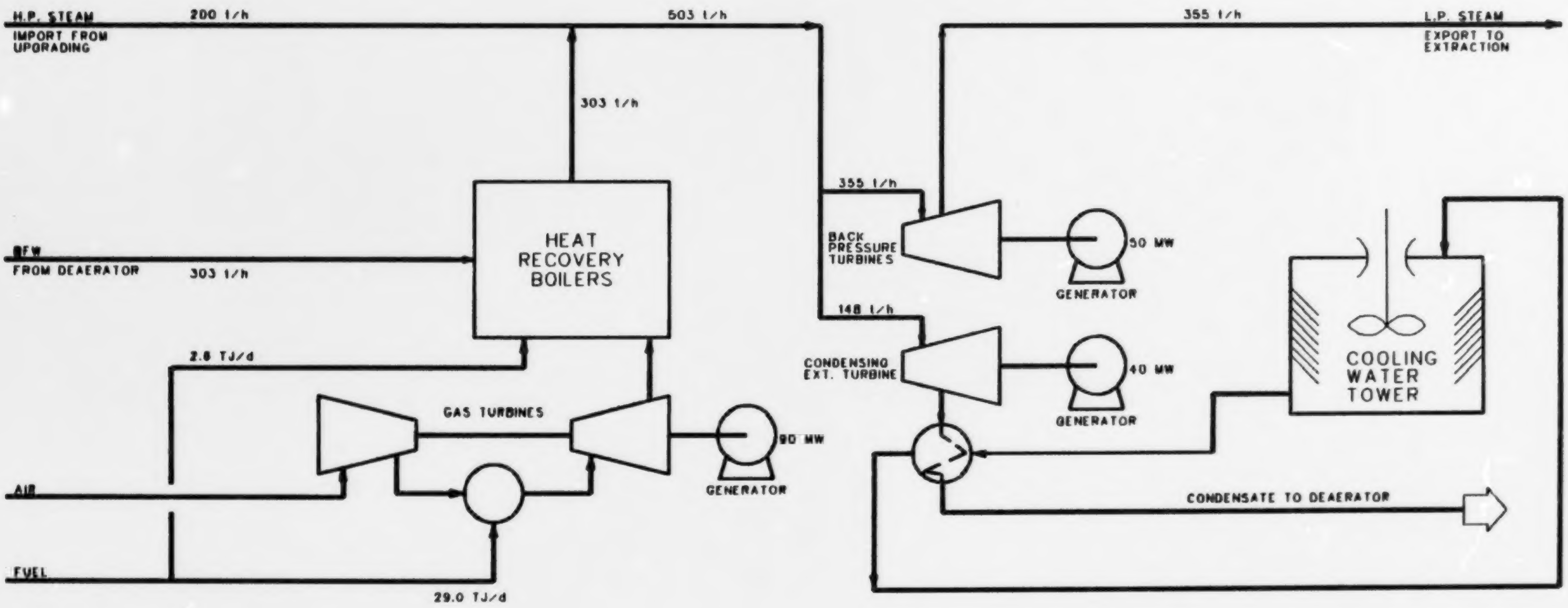
1.3 Energy Balance - Average (Figure 1.2-1)

Power Generation (MW):	
Gas turbine-generators	90
B.P. turbine-generators	50
Condensing/extraction turbine-generators	40
	180

Fuel Requirements (TJ/CD):	
Gas turbines	29.0
Boilers	2.6
	31.6

High Pressure Steam (t/h):	
Imported from upgrading	200
Generated by utility boilers	303
Used by B.P. turbines	355
Used by condensing turbines	148

Low pressure steam (t/h):	
Generated by B.P. turbine for export to extraction	355


H.P. STEAM
IMPORT FROM UPGRADING
200 t/h
503 t/h
303 t/h
355 t/h
L.P. STEAM
EXPORT TO EXTRACTION
BFW
FROM DEAERATOR
303 t/h
HEAT RECOVERY BOILERS
2.8 TJ/d
GAS TURBINES
AIR
FUEL
29.0 TJ/d
90 MW
GENERATOR
355 t/h
BACK PRESSURE TURBINES
50 MW
GENERATOR
148 t/h
CONDENSING EXT. TURBINE
40 MW
GENERATOR
COOLING WATER TOWER
CONDENSATE TO DEAERATOR

EQUIPMENT

3 -	330 t/h BOILERS	(990 t/hr)
3 -	33 MW GTG	(99 MW)
2 -	50 MW BTG	(100 MW)
2 -	30 MW CTG	(60 MW)
	TOTAL	259 MW

ELECTRICITY REQUIRED

MINING	36 MW
EXTRACTION	30 MW
UPGRADING	70 MW
OFFPLOT	28 MW
UTILITIES	16 MW
TOTAL	180 MW (AVGE. DEMAND)

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE:
SIMPLIFIED UTILITY PLANT
FLOW SCHEME
CASE 1
DRAWN BY L.F.
CHECKED BY
DATE 12/03/82
PROJECT No. TM500
DWG No. T55008010
FIGURE 1.2-1

2.0 CASE 2

2.1 Description

This case is identical to Case 1 except for the smaller electrical load in the mining area. As the steam balance for the process areas is unaffected, the only change from Case 1 is reduced generating capacity.

Installed capacity of the condensing turbine generators was reduced accordingly.

2.2 Equipment (Figure 2.2-1)

- Heat recovery boilers (3):
  330 t/h steam generating capacity
  at 6200 kpag and 482°C

- Gas turbine generators (3):
  33 MW capacity

- Back pressure turbine generators (2):
  50 MW capacity
  w/6200 kpag inlet and 350 kpag exhaust

- Condensing/extraction turbine-generators (1):
  25 MW capacity
  w/6200 kpag inlet and 7 kpa (absolute) exhaust

2.3 Energy Balance - Average (Figure 2.2-1)

Power Generation (MW):

Gas turbine-generators	90
B.P. turbine-generators	50
Condensing/extraction turbine-generators	15
	155

Fuel Requirements (TJ/CD):

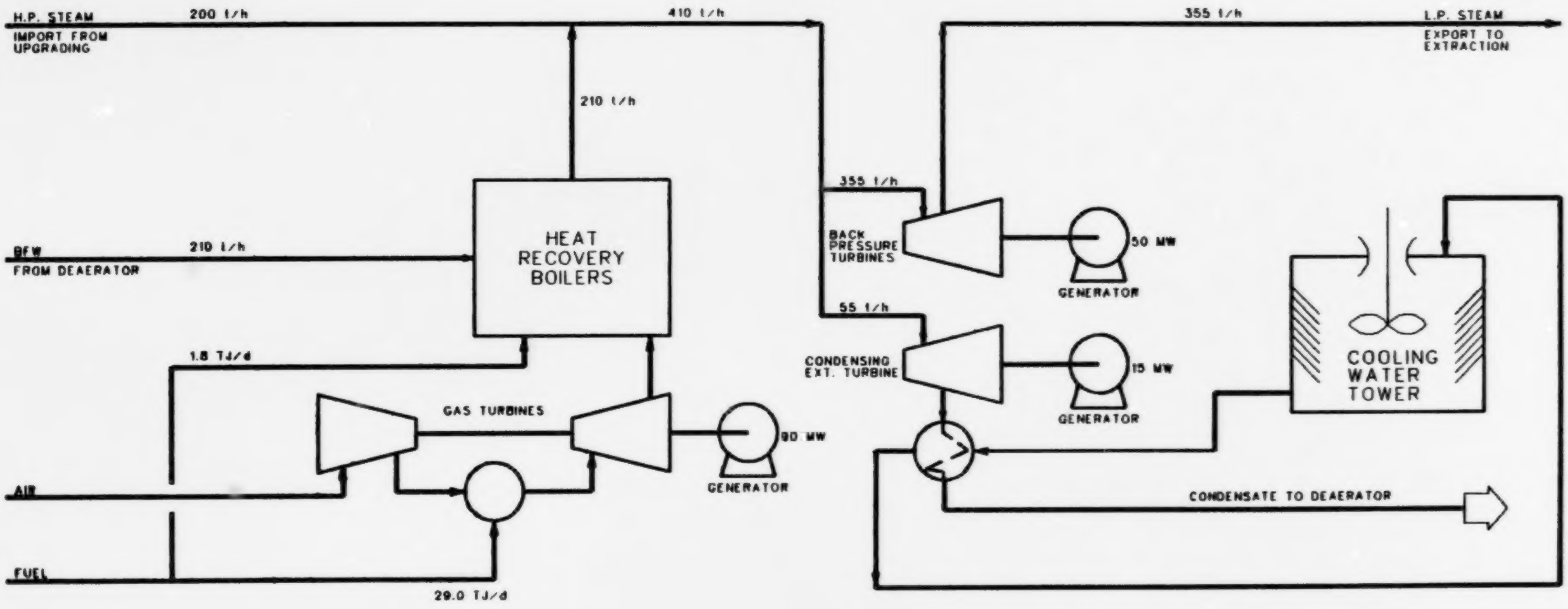
Gas turbines	29.0
Boilers	1.8
	30.8

High Pressure Steam (t/h):

Imported from upgrading	200
Generated by utility boilers	210
Used by B.P. turbines	355
Used by condensing turbines	55

Low Pressure Steam (t/h):

Generated by B.P. turbine for export to extraction	355


H.P. STEAM
IMPORT FROM UPGRADING
200 t/h
410 t/h
355 t/h
L.P. STEAM
EXPORT TO EXTRACTION
210 t/h
HEAT RECOVERY BOILERS
BFW
FROM DEAERATOR
210 t/h
1.8 TJ/d
GAS TURBINES
AIR
FUEL
29.0 TJ/d
90 MW
GENERATOR
355 t/h
BACK PRESSURE TURBINES
50 MW
GENERATOR
55 t/h
CONDENSING EXT. TURBINE
15 MW
GENERATOR
COOLING WATER TOWER
CONDENSATE TO DEAERATOR

EQUIPMENT

3 - 330 t/h BOILERS		(990 t/hr)
3 - 33 MW GTG		(99 MW)
2 - 50 MW BTG		(100 MW)
1 - 25 MW CTG		(25 MW)
	TOTAL	224 MW

ELECTRICITY REQUIRED

MINING		11 MW
EXTRACTION		30 MW
UPGRADING		70 MW
OFFPLOT		28 MW
UTILITIES		16 MW
	TOTAL	155 MW (AVGE DEMAND)

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE:
SIMPLIFIED UTILITY PLANT
FLOW SCHEME
CASE 2
DRAWN BY: L.F.
CHECKED BY: T.S.
DATE: 12/03/82
PROJECT No.: TM500
DWG No.: TS5008011
FIGURE 2.2-1

3.0 CASE 3

3.1 Description

This case is identical in process design to Case 2 but has one quarter of the plant capacity. The configuration of the Utility Plant, with the necessary capacity adjustments, remains essentially unchanged, except in two areas. The condensing/extraction turbine-generators have been eliminated for this case for simplicity of operation. The gas turbine generators were sized to carry all loads in excess of what the back pressure turbine-generators can carry and to be able to absorb any transient load changes.

The single train concept adopted for this case has a significant impact on the steam system. Since the Extraction Plant is expected to shut down whenever upgrading is down, the Utility Plant is not required to supply the heat for extraction hot water which normally comes from upgrading but otherwise is expected to be supplied by the Utility Plant whenever upgrading is down. Consequently, the capacity of the Steam Plant for this case is smaller than that for the two-train design as in Cases 1 and 2.

3.2 Equipment (Figure 3.2-1)

- Heat recovery boilers (3):
  50 t/h steam generating capacity
  at 4150 kpag and 400°C

- Gas turbine-generators (3)
  17 MW capacity

- Back pressure turbine-generators (2)
  10 MW capacity
  w/4150 kpag inlet and 350 kpag exhaust

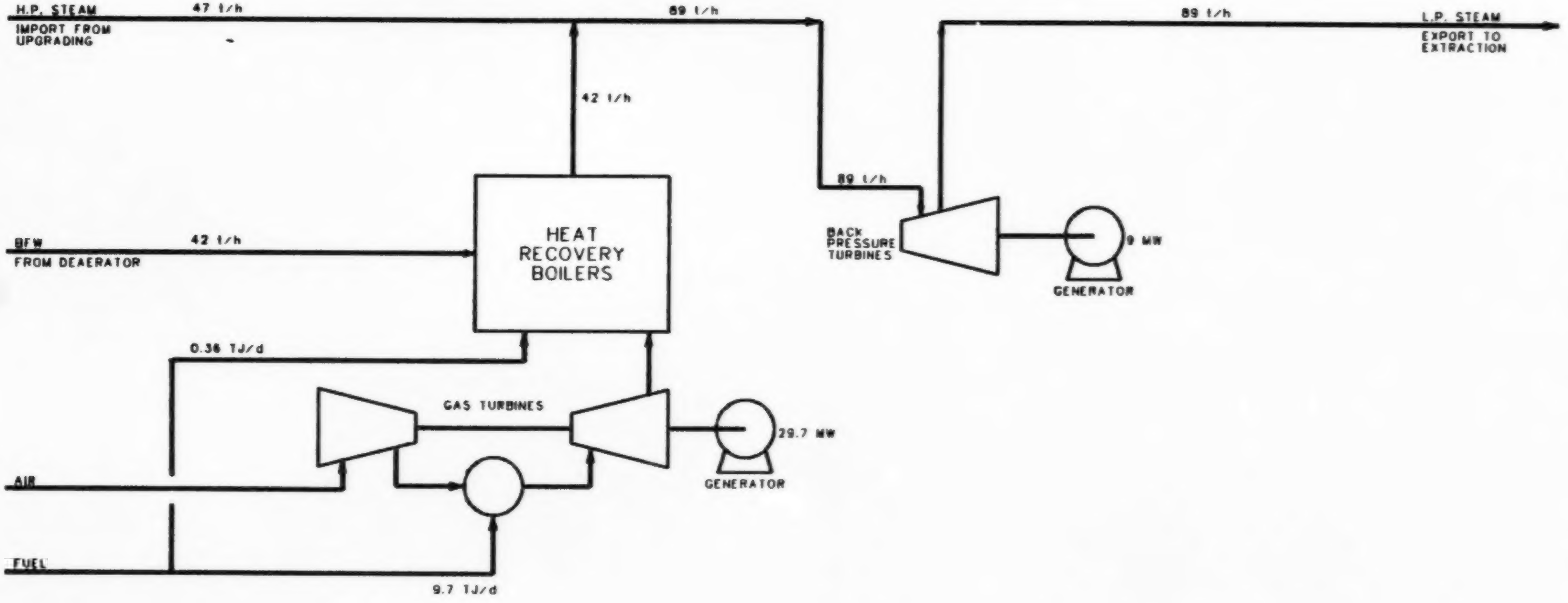
3.3 Energy Balance - Average (Figure 3.2-1)

Power Generation (MW):	
Gas turbine-generators	29.7
B.P. turbine-generators	9.0
	38.7

Fuel Requirements (TJ/CD):	
Gas turbines	9.7
Boilers	0.36
	10.06

High Pressure Steam (t/h):	
Imported from upgrading	47
Generated by utility boilers	42
Used by B.P. turbines	89

Low Pressure Steam (t/h):	
Generated by B.P. turbine for export to extraction	89


H.P. STEAM
IMPORT FROM UPGRADING
47 t/h
89 t/h
42 t/h
BFW
FROM DEAERATOR
42 t/h
HEAT RECOVERY BOILERS
0.36 TJ/d
GAS TURBINES
AIR
FUEL
9.7 TJ/d
GENERATOR
29.7 MW
89 t/h
BACK PRESSURE TURBINES
GENERATOR
9 MW
89 t/h
L.P. STEAM
EXPORT TO EXTRACTION

EQUIPMENT

3 - 50 t/h BOILERS	(150 t/hr)
3 - 17 MW GTG	(51 MW)
2 - 10 MW BTG	(20 MW)
TOTAL	71 MW

ELECTRICITY REQUIRED

MINING	2.7 MW
EXTRACTION	7.5 MW
UPGRADING	17.5 MW
OFFPLOT	7.0 MW
UTILITIES	4.0 MW
TOTAL	38.7 MW (AVGE DEMAND)

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE:
SIMPLIFIED UTILITY PLANT
FLOW SCHEME
CASE 3

DRAWN BY	CHECKED BY	DATE	PROJECT No.
L.F.		12/03/82	TM500

TECHMAN
DWG. No. TS5008012
FIGURE 32-1

4.0 CASE 4

4.1 Description

Case 4 is identical to Case 3 in all respects except for the larger electrical load in the mining area. The capacity of the gas turbine generators was increased to cover the larger demand.

4.2 Equipment (Figure 4.2-1)

- Heat recovery boilers (3):
  50 t/h steam generating capacity
  at 4150 kpag and 400°C

- Gas turbine-generators (3):
  22 MW capacity

- Back pressure turbine-generators (2):
  10 MW capacity
  w/4150 kpag inlet and 350 kpag exhaust

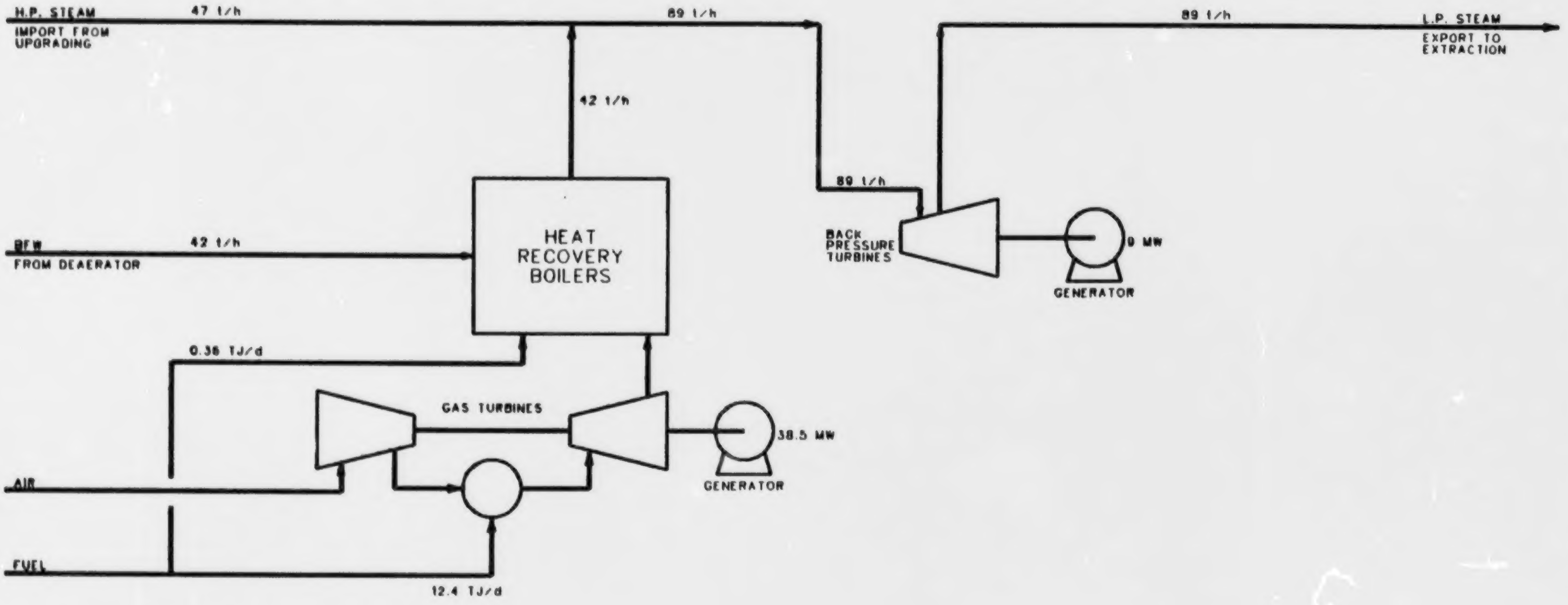
4.3 Energy Balance - Average (Figure 4.2-1)

Power Generation (MW):	
Gas turbine-generators	38.5
B.P. turbine-generators	9
	47.5

Fuel Requirements (TJ/CD):	
Gas turbines	12.4
Boilers	0.36
	12.76

High Pressure Steam (t/h):	
Imported from upgrading	47
Generated by utility boilers	42
Used by B.P. turbines	89

Low Pressure Steam (t/h):	
Generated by B.P. turbine for export to extraction	89


H.P. STEAM
IMPORT FROM UPGRADING
47 t/h
89 t/h
42 t/h
BFW
FROM DEAERATOR
42 t/h
HEAT RECOVERY BOILERS
0.36 TJ/d
GAS TURBINES
38.5 MW
GENERATOR
AIR
FUEL
12.4 TJ/d
89 t/h
BACK PRESSURE TURBINES
0 MW
GENERATOR
89 t/h
L.P. STEAM
EXPORT TO EXTRACTION

EQUIPMENT

3 - 50 t/h BOILERS	(150 t/hr)
3 - 22 MW GTG	(66 MW)
2 - 10 MW BTG	(20 MW)
TOTAL	86 MW

ELECTRICITY REQUIRED

MINING	11.5 MW
EXTRACTION	7.5 MW
UPGRADING	17.5 MW
OFFPLOT	7.0 MW
UTILITIES	4.0 MW
TOTAL	47.5 MW (AVGE. DEMAND)

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES

PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY

DRAWING TITLE:
SIMPLIFIED UTILITY PLANT
FLOW SCHEME
CASE 4

DRAWN BY	CHECKED BY	DATE	PROJECT No.:
L.F.	G?	12/03/82	TM500

DWG No.: TS5008013

FIGURE 4.2-1

5.0 CASE 5

5.1 Description

5.1.1 Initial Phase

The initial phase for this case is essentially identical to Case 3. The concept of the utility design is also unchanged from Case 3. The sizes and numbers of the generators, however, have been selected to facilitate build-up to the final phase.

5.1.2 Final Phase

The basic concept of the Utility Plant design for the final phase of this case remains unchanged from Case 1 or 2. The energy balance has changed, however, due to the use of the H-Oil process in upgrading. Upgrading for this case consumes more steam than it produces and, therefore, imports steam from the Utility Plant. Upgrading also uses less power than Case 1 or 2.

The above factors coupled with the two stage build-up precipitated a final plant configuration which has a greater number of boilers and generators, greater steam capacity and smaller electric generating capacity than Case 1 or 2.

5.2 Equipment

5.2.1 Initial Phase (Figure 5.2-1A)

- Heat recovery boilers (3):
  50 t/h steam-generating capacity
  at 6200 kpag and 482°C

- Gas turbine-generators (2):
  22 MW capacity

- Back pressure turbine-generators (1)
  20 MW capacity
  w/6200 kpag inlet and 350 kpag exhaust

5.2.2 Final Phase (Figure 5.2-1B)

- Heat recovery boilers:
  - 50 t/h steam generating capacity (3)
    at 6200 kpag and 482°C
  - 400 t/h steam generating capacity (3)
    at 6200 kpag and 482°C

- Gas turbine-generating capacity (4):
  22 MW capacity

- Back pressure turbine-generators (3):
  20 MW capacity (1)
  40 MW capacity (2)
  w/6200 kpag inlet and 350 kpag exhaust

- Condensing/extraction turbine-generators (1):
  10 MW capacity
  w/6200 kpag inlet and 7 kpa (absolute) exhaust

5.3 Energy Balance (Average)

5.3.1 Initial Phase (Figure 5.2-1A)

Power Generation (MW):	
Gas turbine-generators	18.7
B.P. turbine-generators	12.5
	31.2

Fuel Requirements (TJ/CD):	
Gas turbines	6.0
Boilers	0.36
	6.36

High Pressure Steam (t/h):	
Imported from upgrading	47
Generated by utility boilers	42
Used by B.P. turbines	89

Low Pressure Steam (t/h):	
Generated by B.P. turbine for export to extraction	89

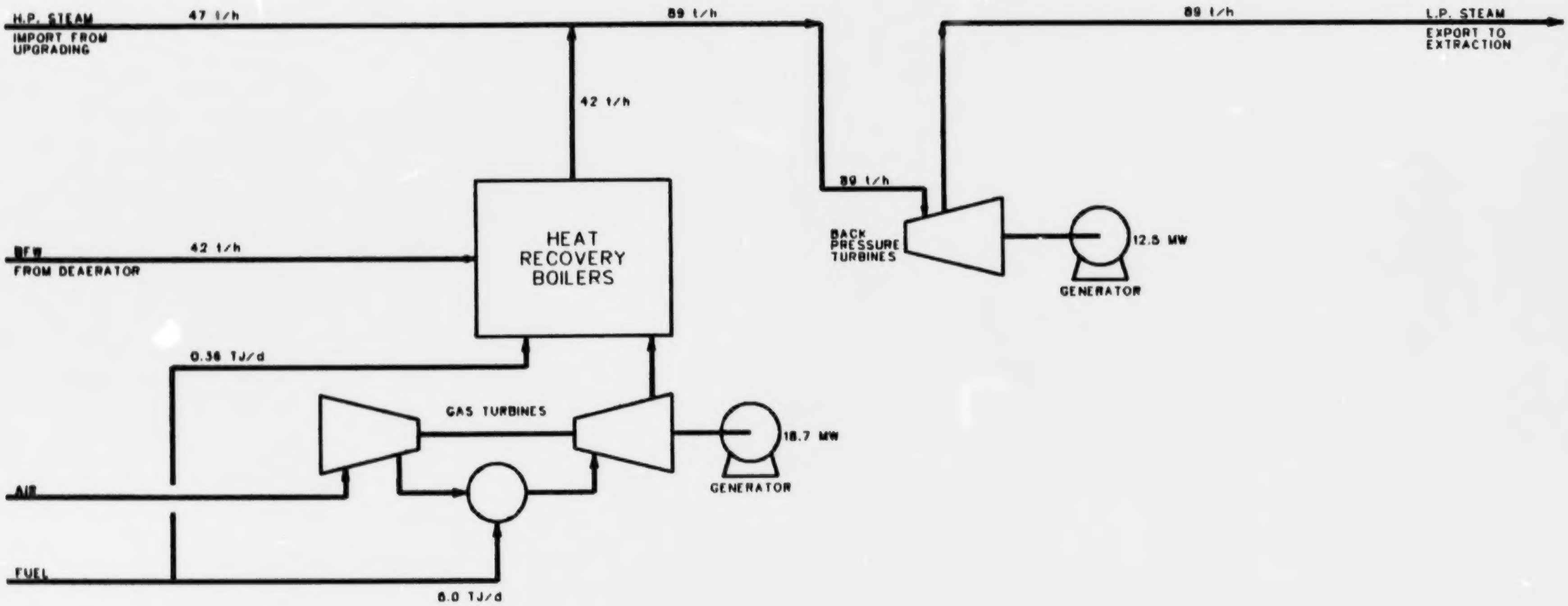
5.3.2 Final Phase (Figure 5.2-1B)

Power Generation (MW):	
Gas turbine-generators	80
B.P. turbine-generators	50
Condensing/extraction turbine generators	4
	135

Fuel Requirements (TJ/CD):	
Gas turbines	25.7
Boilers	4.0
	29.7

High Pressure Steam (t/h):	
Exported to upgrading	100
Generated by utility boilers	470
Used by B.P. turbines	355
Used by condensing turbines	15

Low Pressure Steam (t/h):	
Generated by B.P. turbine for export to extraction	355


H.P. STEAM
IMPORT FROM UPGRADING
47 t/h
89 t/h
89 t/h
L.P. STEAM
EXPORT TO EXTRACTION
42 t/h
89 t/h
BACK PRESSURE TURBINES
12.5 MW
GENERATOR
BFW
FROM DEAERATOR
42 t/h
HEAT RECOVERY BOILERS
0.36 TJ/d
GAS TURBINES
18.7 MW
GENERATOR
AIR
FUEL
8.0 TJ/d

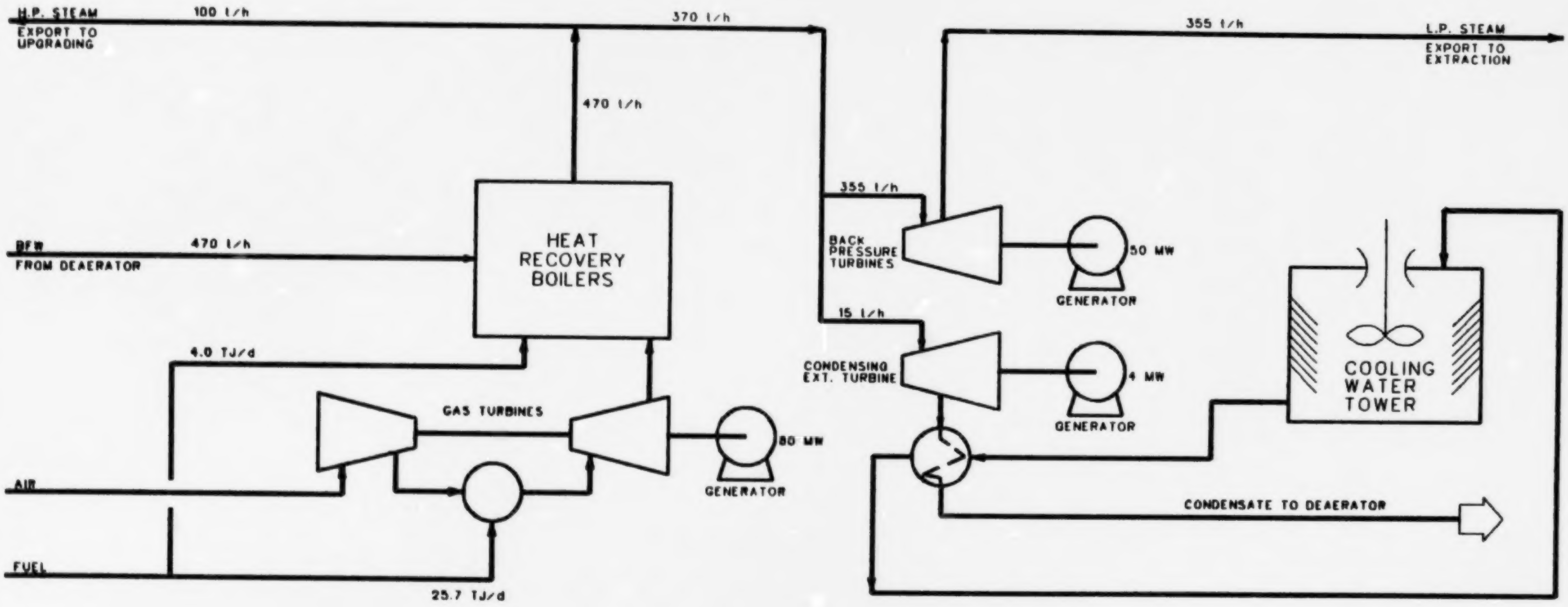
EQUIPMENT

3 - 50 t/h BOILERS		(150 t/hr)
2 - 22 MW GTG		(44 MW)
1 - 20 MW BTG		(20 MW)
	TOTAL	84 MW

ELECTRICITY REQUIRED

MINING		2.7 MW
EXTRACTION		7.5 MW
UPGRADING		10.0 MW
OFFPLOT		7.0 MW
UTILITIES		4.0 MW
	TOTAL	31.2 MW (AVGE. DEMAND)

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE:
SIMPLIFIED UTILITY PLANT
FLOW SCHEME
CASE 5 – INITIAL STAGE
DRAWN BY: L.F.
CHECKED BY:
DATE: 12/03/82
PROJECT No.: 1M500
DWG No.: TS5008014
TECHMAN
FIGURE 5.2-1A


H.P. STEAM
EXPORT TO UPGRADING
100 t/h
370 t/h
470 t/h
BFW
FROM DEAERATOR
470 t/h
HEAT RECOVERY BOILERS
4.0 TJ/d
GAS TURBINES
AIR
FUEL
25.7 TJ/d
80 MW
GENERATOR
355 t/h
BACK PRESSURE TURBINES
50 MW
GENERATOR
15 t/h
CONDENSING EXT. TURBINE
4 MW
GENERATOR
355 t/h
L.P. STEAM
EXPORT TO EXTRACTION
COOLING WATER TOWER
CONDENSATE TO DEAERATOR

EQUIPMENT

3 - 50 t/h BOILERS		(150 t/hr)
3 - 400 t/h BOILERS		(1200 t/h)
	TOTAL	1350 t/h
4 - 22 MW GTG		(88 MW)
1 - 20 MW BTG		(20 MW)
2 - 40 MW BTG		(80 MW)
1 - 10 MW CTG		(10 MW)
	TOTAL	198 MW

ELECTRICITY REQUIRED

MINING		11 MW
EXTRACTION		30 MW
UPGRADING		49 MW
OFFPLOT		28 MW
UTILITIES		16 MW
	TOTAL	134 MW (AVGE. DEMAND)

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME:
ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE:
SIMPLIFIED UTILITY PLANT
FLOW SCHEME
CASE 5 - FINAL STAGE
DRAWN BY L.F.
CHECKED BY
DATE 12/03/82
PROJECT No. TM500
DWG No. T55008015
TECHMAN
FIGURE 5.2-1B

6.0 CASE 6

6.1 Description

As this case entails the physical separation of the upgrading units from the mining/extraction complex, the impact on the utility systems is quite significant.

Since the system is not integrated, the opportunity for energy optimization is severely curtailed. The large quantity of low level heat from upgrading can no longer be used to heat hot water for the Extraction Plant and would be largely wasted. The flexibility of an integrated system is no longer available. Two separate Utility Plants would be required.

On the other hand, the operation of the utility system would be far simpler, having to deal with less combinations of operating modes.

The design concept of the utility systems for this case is that there would be no self-generation of electricity other than emergency power and electricity would be totally imported from the outside power grid at both locations.

Thus, the Utility Plant at each location would only produce required steam and hot water.

6.1.1 Mining/Extraction Complex - Fort McMurray Area

The Utility Plant consists of steam generators, hot water exchangers, water treatment facilities and ancillaries.

The steam generators are of an once-through oil field packaged type which produce high pressure wet steam and require minimal water treatment. Because of the large amount of live steam required for the extraction process and consequently the need for a large quantity of make-up water the once-through generators with tolerance for low quality feed water are more suitable for the application.

Steam is produced by the steam generators at approximately 3,500 kpa and 80 percent saturated. Pressure of this wet steam is reduced to 350 kpa through a pressure reducing station. The low pressure steam produced is in turn supplied to the Extraction Plant for the extraction process and to the hot water exchangers where it is used for heating the extraction hot water.

The condensate from the exchangers is recycled to the boilers through the deaerators.

Natural gas is used as fuel for the generators.

6.1.2 Upgrading Complex - Edmonton Area

The features of the Utility Plant include packaged steam generators, make-up water treatment facilities, a compressed air system and required ancilliaries.

The steam boilers produces steam at 4150 kpa, and 400°C which is supplied to all areas in the complex. Compressed air for plant and instrument use is also supplied from the Utility Plant. The water treatment plant treats the necessary make-up water.

The reliability of the grid in the Edmonton area is expected to be such that the minimum emergency power system is required at the plant to ensure the continuity of the essential process operation. The plant fuel gas from upgrading is used for the boilers.

6.2 Equipment

6.2.1 Initial Phase (Figure 6.2-1A)

6.2.1.1 Fort McMurray Area

- Once-through packaged steam generators (4):
  80 t/h steam generating capacity
  at 3500 kpag and 80 percent saturation

6.2.1.2 Edmonton Area

- Packaged steam generators (2):
  100 t/h steam generating capacity
  at 4150 kpag and 400°C

6.2.2 Final Phase (Figure 6.2-1B)

6.2.2.1 Fort McMurray Area

- Once-through packaged steam generators (14):
  80 t/h steam generating capacity
  at 3500 kpag and 80 percent saturation

6.2.2.2 Edmonton Area

- Packaged steam generators (4):
  100 t/h capacity
  at 4150 kpag and 400°C

6.3 Energy Balance (Average)

6.3.1 Initial Phase (Figure 6.2-1A)

6.3.1.1 Fort McMurray Area

Average power import from grid (MW)	15.2
Fuel requirements (natural gas) (TJ/CD)	11.7
High pressure steam generated (t/h)	167
Low pressure steam to extraction (t/h)	89
Hot water to extraction (m^3/h)	647

6.3.1.2 Edmonton Area

Average power import from grid (MW)	17
Fuel requirements (TJ/CD)	6.3
Steam generated (t/h)	75.6

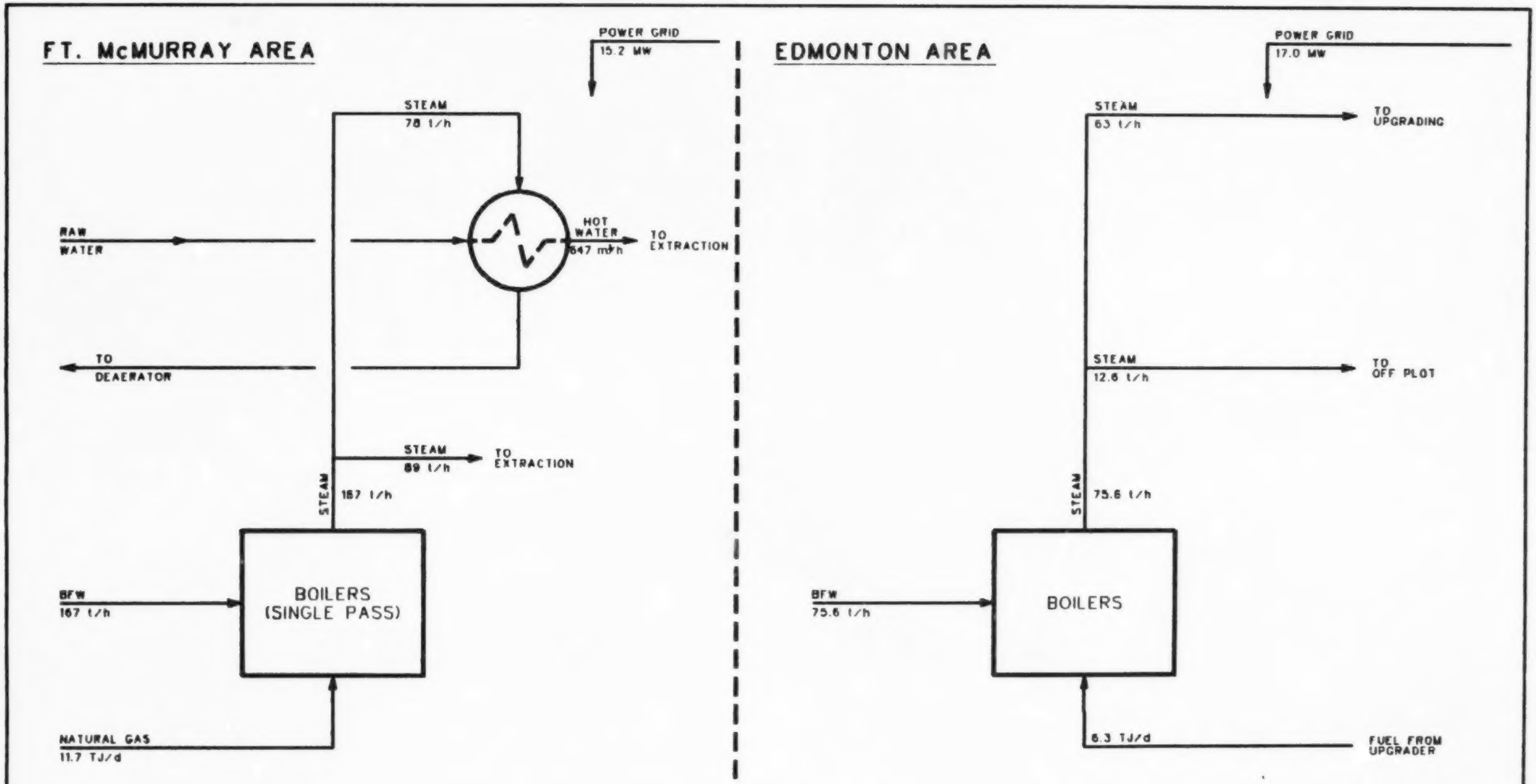
6.3.2 Final Phase (Figure 6.2-1B)

6.3.2.1 Fort McMurray Area

Average power impact from grid (MW)	61
Fuel requirements (natural gas) (TJ/CD)	46.7
High pressure steam generated (t/h)	670
Low pressure steam to extraction	355
Low pressure steam to exchangers	315
Hot water to extraction (m^3/h)	2586

6.3.2.2 Edmonton Area

Average power import from grid (MW)	84
Fuel requirements (20 TJ/CD)	20
Steam generated (t/h)	238


FT. McMURRAY AREA
POWER GRID
15.2 MW
STEAM
78 t/h
RAW WATER
HOT WATER
647 m^3/h
TO EXTRACTION
TO DEAERATOR
STEAM
89 t/h
TO EXTRACTION
STEAM
167 t/h
BFW
167 t/h
BOILERS (SINGLE PASS)
NATURAL GAS
11.7 TJ/d
EDMONTON AREA
POWER GRID
17.0 MW
STEAM
63 t/h
TO UPGRADING
STEAM
12.6 t/h
TO OFF PLOT
STEAM
75.6 t/h
BFW
75.6 t/h
BOILERS
6.3 TJ/d
FUEL FROM UPGRADER

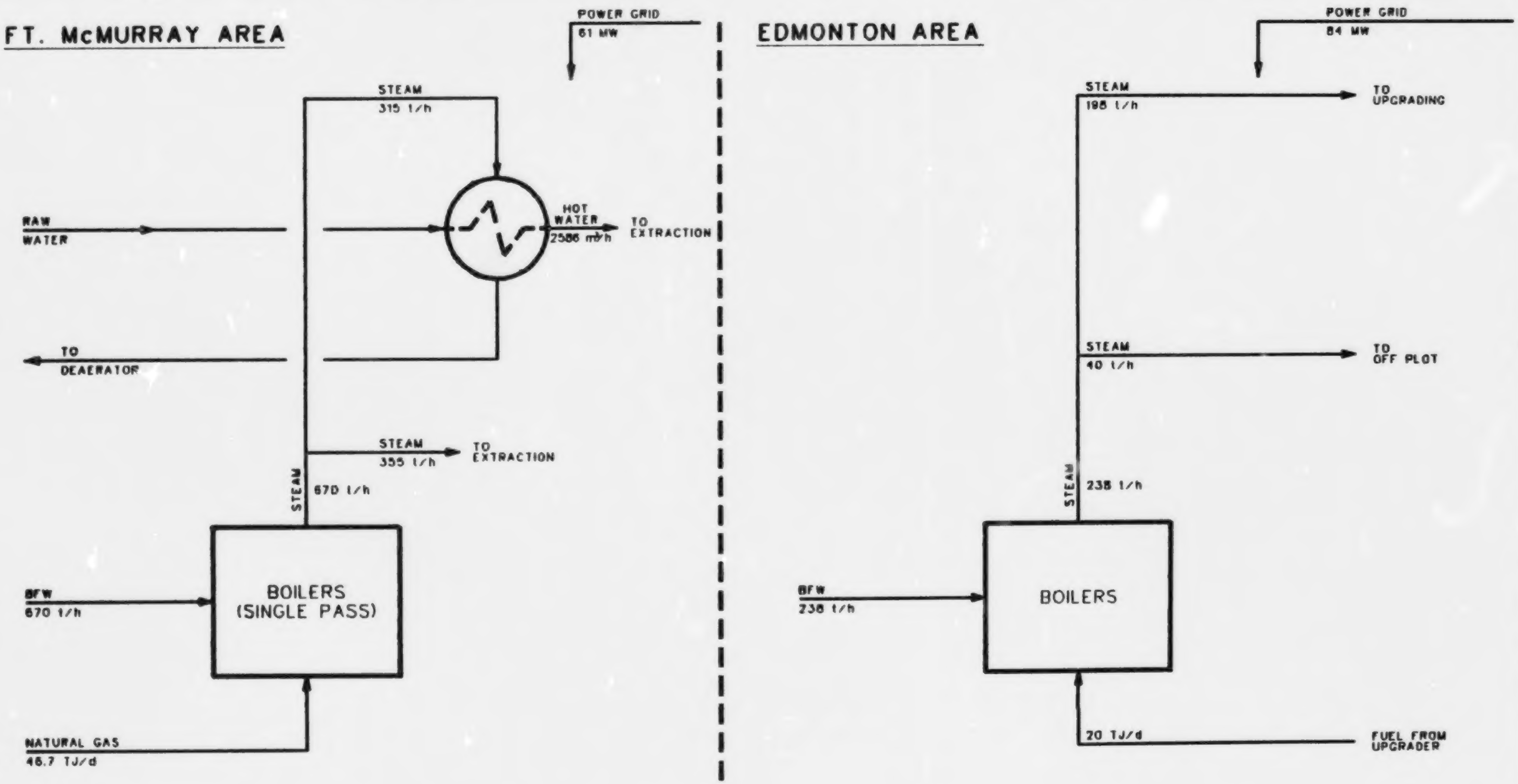
ELECTRICITY REQUIRED

MINING	2.7 MW
EXTRACTION	7.5 MW
BPU	1.0 MW
OFFPLOT & UTILITIES	4.0 MW
TOTAL	15.2 MW (AVG. DEMAND)

ELECTRICITY REQUIRED

UPGRADING	7.0 MW
OFF PLOT	6.5 MW
UTILITIES	3.5 MW
TOTAL	17.0 MW (AVG. DEMAND)

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE
SIMPLIFIED UTILITY
PLANT FLOW SCHEME
CASE 6 – INITIAL STAGE
DRAWN BY T.F.W.
CHECKED BY
DATE 12/03/82
PROJECT No. TM500
DWG No. TS5008016
TECHMAN
FIGURE 6.2-1A


FT. McMURRAY AREA
POWER GRID
61 MW
STEAM
315 t/h
RAW WATER
HOT WATER
2586 m³/h
TO EXTRACTION
TO DEAERATOR
STEAM
355 t/h
TO EXTRACTION
STEAM
670 t/h
BFW
670 t/h
BOILERS (SINGLE PASS)
NATURAL GAS
46.7 TJ/d
EDMONTON AREA
POWER GRID
84 MW
STEAM
198 t/h
TO UPGRADING
STEAM
40 t/h
TO OFF PLOT
STEAM
238 t/h
BFW
238 t/h
BOILERS
20 TJ/d
FUEL FROM UPGRADER

ELECTRICITY REQUIRED

MINING	11 MW
EXTRACTION	30 MW
BPU	4 MW
OFFPLOT & UTILITIES	16 MW
TOTAL	61 MW (AVG. DEMAND)

ELECTRICITY REQUIRED

UPGRADING	44 MW
OFF PLOT	26 MW
UTILITIES	14 MW
TOTAL	84 MW (AVG. DEMAND)

CLIENT: GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME: ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE: SIMPLIFIED UTILITY
PLANT FLOW SCHEME
CASE 6 – FINAL STAGE
DRAWN BY: T.F.W.
CHECKED BY: GS.
DATE: 12/03/82
PROJECT No.: TM500
DWG No.: T55008017
FIGURE 6.2-1B

7.0 CASE 7

7.1 Description

Case 7 is the same as half of Case 2. The configuration of the utilities is identical to Case 2 and the energy balances are exactly one half of Case 2.

Only the generating capacity has been slightly changed in order to choose a standard size gas turbine.

7.2 Equipment (Figure 7.2-1)

- Heat recovery boilers (3):
  165 t/h steam generating capacity
  at 6200 kpag and 482°C

- Gas turbine-generators (3):
  17 MW capacity

- Back pressure turbine-generators (2):
  25 MW capacity
  w/6200 kpag inlet and 360 kpag exhaust

- Condensing/extraction turbine-generators (1):
  12 MW capacity
  w/6200 kpag inlet and 7kpa (absolute) exhaust

7.3 Energy Balance - Average (Figure 7.2-1)

Power Generation (MW):

Gas turbine-generators	45
B.P. turbine-generators	25
Condensing/extraction turbine-generators	7.5
	77.5

Fuel Requirements (TJ/CD):

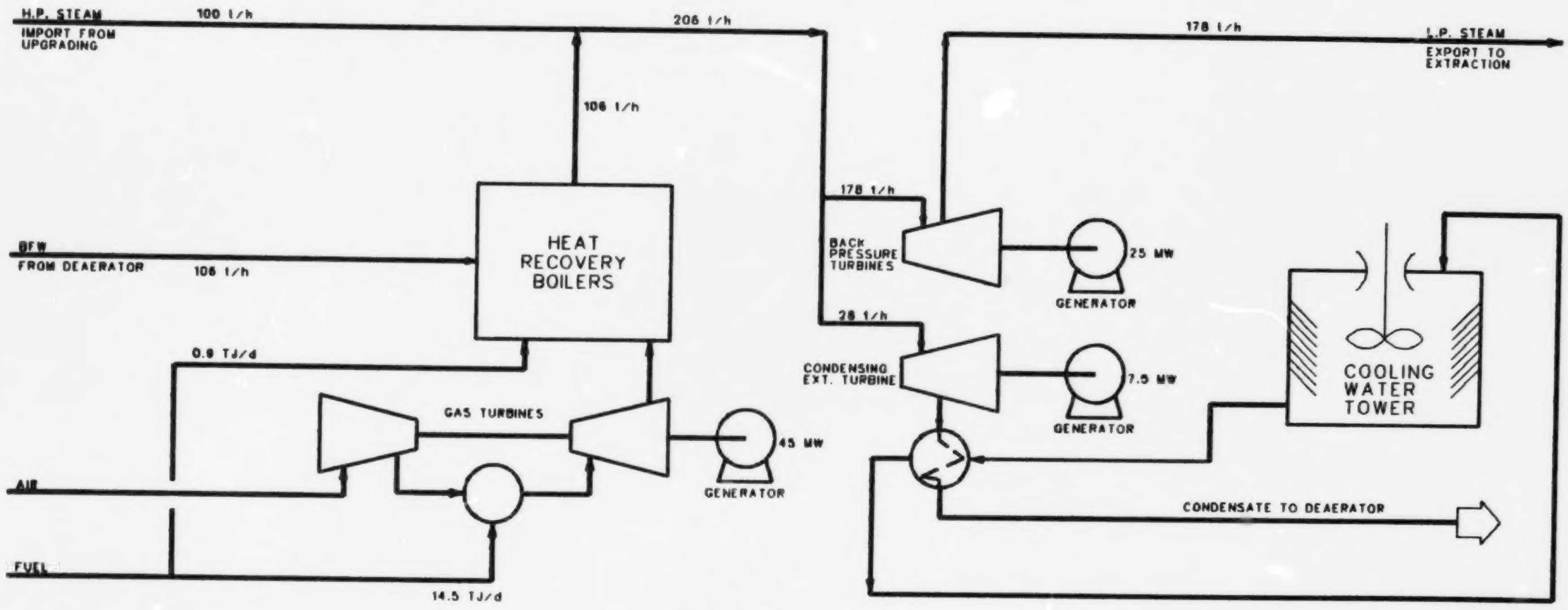
Gas turbines	14.5
Boilers	0.9
	15.4

High Pressure Steam (t/h):

Imported from upgrading	100
Generated by utility boilers	106
Used by B.P. turbines	178
Used by condensing turbines	28

Low Pressure Steam (t/h):

Generated by B.P. turbine for export to extraction	178


H.P. STEAM
IMPORT FROM UPGRADING
100 t/h
206 t/h
106 t/h
BFW
FROM DEAERATOR
106 t/h
HEAT RECOVERY BOILERS
0.9 TJ/d
GAS TURBINES
AIR
FUEL
14.5 TJ/d
45 MW
GENERATOR
178 t/h
BACK PRESSURE TURBINES
25 MW
GENERATOR
28 t/h
CONDENSING EXT. TURBINE
7.5 MW
GENERATOR
178 t/h
L.P. STEAM
EXPORT TO EXTRACTION
COOLING WATER TOWER
CONDENSATE TO DEAERATOR

EQUIPMENT

3 - 165 t/h BOILERS	(495 t/hr)
3 - 17 MW GTG	(51 MW)
2 - 25 MW BTG	(50 MW)
1 - 12 MW CTG	(12 MW)
TOTAL	113 MW

ELECTRICITY REQUIRED

MINING	5.5 MW
EXTRACTION	15.0 MW
UPGRADING	35.0 MW
OFFPLOT	14.0 MW
UTILITIES	8.0 MW
TOTAL	77.5 MW (AVGE. DEMAND)

CLIENT: GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME: ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE: SIMPLIFIED UTILITY PLANT
FLOW SCHEME
CASE 7
DRAWN BY L.F.
DATE 12/07/82
PROJECT No. TM500
DWG. No. TS5008024
FIGURE 7.2-1

8.0 Case 8

8.1 Description

Case 8 is identical to the initial phase of Case 6 except that Case 8 has twice the capacity and it is built in a single stage. The utility configuration for both locations are the same and the figures on energy balances are double the initial phase of Case 6.

8.2 Equipment (Figure 8.2-1)

8.2.1 Fort McMurray Area

- Once-through package steam generators (8)
  80 t/h capacity
  at 3500 kpag and 80 percent saturation

8.2.2 Edmonton Area

- Packaged steam generators (3):
  100 t/h capacity
  at 4150 kpag and 400°C

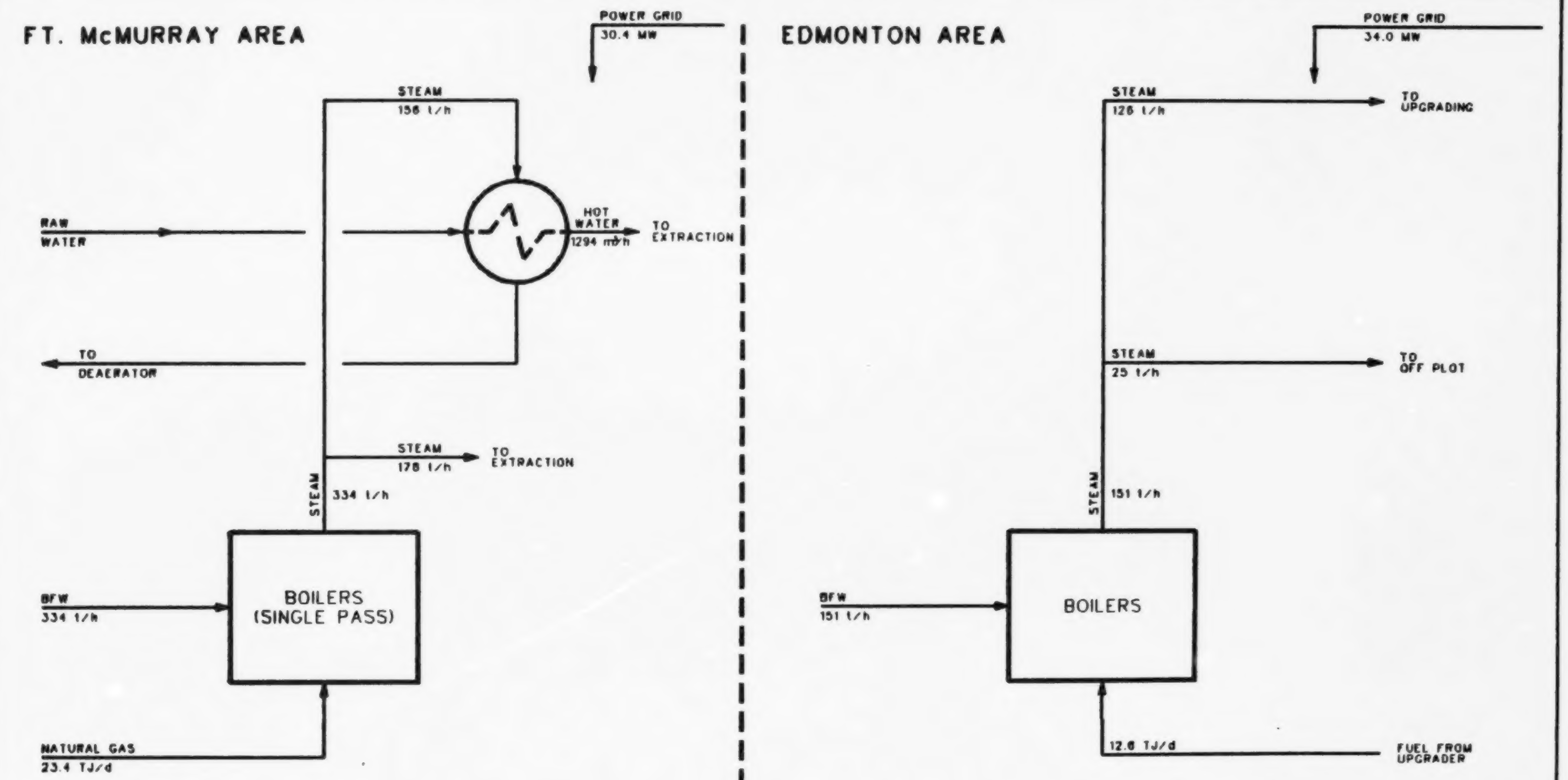
8.3 Energy Balance - Average (Figure 8.2-1)

8.3.1 Fort McMurray Area

Average power imported from grid (MW)	30.4
Fuel requirements (natural gas) (TJ/CD)	23.4
High pressure steam generated (t/h)	334
Low pressure steam to extraction (t/h)	178
Low pressure steam to exchangers (t/h)	156
Hot water to extraction (m^3/h)	1294

8.3.2 Edmonton Area

Average power imported from grid (MW)	34
Fuel requirements (TJ/CD)	12.6
Steam generated (t/h)	151


FT. McMURRAY AREA
POWER GRID
30.4 MW
STEAM
156 t/h
RAW WATER
HOT WATER
1294 m³/h
TO EXTRACTION
TO DEAERATOR
STEAM
178 t/h
TO EXTRACTION
STEAM
334 t/h
BFW
334 t/h
BOILERS (SINGLE PASS)
NATURAL GAS
23.4 TJ/d
EDMONTON AREA
POWER GRID
34.0 MW
STEAM
126 t/h
TO UPGRADING
STEAM
25 t/h
TO OFF PLOT
STEAM
151 t/h
BFW
151 t/h
BOILERS
12.6 TJ/d
FUEL FROM UPGRADER

ELECTRICITY REQUIRED

MINING	5.4 MW
EXTRACTION	15.0 MW
BPU	2.0 MW
OFFPLOT & UTILITIES	8.0 MW
TOTAL	30.4 MW (AVG. DEMAND)

ELECTRICITY REQUIRED

UPGRADING	14.0 MW
OFF PLOT	13.0 MW
UTILITIES	7.0 MW
TOTAL	34.0 MW (AVG. DEMAND)

CLIENT:
GOVERNMENT OF CANADA
ENERGY, MINES AND RESOURCES
PROJECT NAME
ALTERNATE TARSANDS DEVELOPMENT STUDY
DRAWING TITLE
SIMPLIFIED UTILITY
PLANT FLOW SCHEME
CASE 8
DRAWN BY T.F.W.
CHECKED BY
DATE 12/09/82
PROJECT No.: TM500
DWG No.: TS5008026
FIGURE 8.2-1

9.0 Case 9

This case is identical to the final phase of Case 6 in all respects.

TARSANDS DEVELOPMENT STUDY

STAGE I

EXECUTIVE SUMMARY

SUBMITTED BY

TECHMAN ENGINEERING LTD.

Work on this project was conducted under the auspices
of the Canada Centre for Mineral and Energy Technology,
Energy, Mines and Resources, Canada

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DSS Contract Serial Number: 1SQ82-00103
CANMET Project Number: 23440-2-9131
CANMET Scientific Authority: Mr. V. Srajer

13pp

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Dereng Enterprises Ltd.

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Oil Sands Development
Shell Canada Resources Limited

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Manager Oil Sands Technology
Alternate Fuels
Cities Service Company

Their free and full participation contributed in a major way to the success of Stage I of the study: the assumptions, conclusions and recommendations documented herein, however, are the sole responsibility of Techman Engineering Ltd. and are not represented to be a reflection of the opinions of individual members of the Concept Development Team, nor of their companies or agencies.

In describing the cases examined in this study, reference is made to certain proprietary processes in extraction and upgrading and to specific equipment items in mining. These references are illustrative and do not represent an endorsement of particular equipment items or manufacturers, nor do they reflect an opinion on the relative suitability of processes in certain applications since Stage I did not include process optimization or any detailed comparative evaluation of competing processes. Processes were selected primarily on the basis of proven technology.

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3.0 RECOMMENDATIONS 3

4.0 APPROACH AND METHODOLOGY 4
  4.1 The Concept Development Team 4
    4.1.1 Summary of Concept Development Team Conclusions 5
  4.2 Role of Techman Engineering Ltd. 6

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1.0 OBJECTIVES OF THE STUDY

To define one or more surface mineable tarsands development schemes, addressing considerations of alternative technologies, scale, ownership and structure, government policy and practice, regional and industrial benefits, national benefits, etc., that in the anticipated operating and market environment are economically viable, financeable, acceptable from a risk standpoint and manageable in scope.

A secondary objective is to identify potential technology enhancements that would significantly improve the best schemes and develop plans to bring the identified potential technology enhancements to a level of commercial and industry acceptability.

2.0 CONCLUSIONS

Based on the comparative analysis of the selected cases, the preliminary conclusions arising out of the Stage I analysis are:

- a smaller scale, fully integrated plant appears relatively attractive on the basis of maximum economic performance and minimum financial exposure as measured by payback time and sunk capital.
- a build-up case, where the operator makes an initial investment in a smaller plant, and subsequently expands to a large plant partially financed out of cash flow generated by the smaller plant, appears attractive;
- a modular mining concept, based on the innovative use of mobile equipment in a way that minimizes haul distances, has been developed by Techman Engineering Ltd., and appears particularly suitable for smaller developments or build-up cases;
- several potential technology enhancements have been identified and qualitatively described in Stage I of the study. Additional work is required to quantify the driving force for development and incorporation of these enhancements; and
- new mining and extraction facilities supplying bitumen to Syncrude Canada Ltd., Suncor Inc. or to certain existing Edmonton area refineries, appear to have good potential. These schemes each require a special business arrangement, and capital and operating cost data that can only be developed with the participation and assistance of the owners and, therefore, have not been examined in detail in Stage I.

The schedule and budget requirements of Stage I were such that the cost data developed is of low accuracy and there was no attempt to optimize any of the cases examined. The above conclusions, therefore, should be regarded as directional only, and it is our opinion that the quality of the data supports this limited interpretation and use.

3.0 RECOMMENDATIONS

Using the directional information developed in Stage I, it is our recommendation that Stage II proceed immediately to develop additional, improved quality data to confirm the preliminary results and to select the best schemes. Specifically, cases should be designed, optimized and examined to:

- confirm the attractiveness of smaller sized plants and to determine the optimum smaller size;
- further examine the build-up case, to confirm its attractiveness, determine best initial size and optimal build-up increments, and select best technologies;
- further develop the modular, mobile equipment mining schemes;
- identify potential technology enhancements and, as far as possible, quantify the driving force for development and incorporation; and
- examine the remote upgrading scenario by:
  - developing costs for stand alone remote mining/extraction facilities
  - developing costs for the "grass-roots" remote upgrader
  - gathering preliminary data for the associated upgraders to be located at existing tarsands plants or refineries.

4.0 APPROACH AND METHODOLOGY

4.1 The Concept Development Team

As one of the first activities in the study, Techman Engineering Ltd. assembled a team comprised of nine representatives of six owner companies or government agencies with present or potential interest in surface mineable tarsands, four outside consultants with specific areas of expertise, and seven Techman Engineering Ltd. personnel. This team, identified as the Concept Development Team, undertook the following tasks:

- identify the criteria for evaluation and selection of the best development schemes from among alternates;
- identify alternate development scenarios for examination; and
- review TEL's work and results at various stages of the study.

The evaluation criteria were developed in the form of "Musts" and "Wants" for subsequent use in a Kepner-Tregoe (K-T) evaluation of selected alternates. The alternate development scenarios took into account various combinations of size, technology, ownership and structure. The sizes considered ranged from 4k m^3/CD (25,000 BPCD) to 15.9k m^3/CD (100,000 BPCD) of bitumen feed to the upgrader. Also identified were the build-up cases, where an operator would commence operations at 4k m^3/CD (25,000 BPCD) and subsequently expand to 15.9k m^3/CD (100,000 BPCD) of bitumen feed. The technological considerations addressed both proven and developing technologies and qualitatively identified the driving force for development and incorporation of potential technology enhancements. In the area of ownership and structure, the Concept Development Team identified cases with integrated extraction and upgrading, remote upgrading, non-integrated but local upgrading, and cases "piggybacked" onto existing plants.

4.1.1 Summary of Concept Development Team Conclusions

The group concluded that there were no "Musts" that would be of use as discriminators in selecting the best case from among alternates, but that there was a "Must" relating to the Business/ Project Development/Project Execution/Plant Operation Environment that would have to be in place for any project to proceed, regardless of its technical and economic merit.

An operator would probably not proceed with a project unless he was satisfied that policies were in place relative to pricing, royalties and taxation that would allow him to recover his investment costs, provide a return on that investment commensurate with the risk and reward innovation and efficiency. He would further require that these policies would be stable over time. Additionally, operators require an improved approvals process and a way of interfacing with governments that facilitates decision-making from the outset of the project. A more complete statement of this "Must" is contained within Section 4.4 of the report.

The "Wants", as identified by the Concept Development Team, and their relative weights are listed below:

• maximize economic performance	10
• minimize financial risk	9
• maximize operability	8
• minimize technical risk	8
• maximize expandability	4
• minimize adverse environmental impact	4
• optimize resource utilization	4
• minimize administrative complexity	4
• maximize Canadian and regional benefits	2
• minimize adverse socio-economic impacts	2

4.2 Role of Techman Engineering Ltd.

From the matrix of cases developed by the Concept Development Team, Techman Engineering Ltd. made a selection of nine cases which would separately test the effects of size, technology, ownership and structure relative to the base case project. These cases would be evaluated against the "Wants" identified by the Concept Development Team. The cases selected would also cover the range of project options that would allow development of base case data and point in the direction of optimality as regards to size, technology and structure.

The nine selected cases were designed as far as necessary to develop energy and material balances, concepts for utilities systems, and to obtain capital and operating cost data and project development schedules. All of the generated data were processed through Techman Engineering Ltd.'s economic model to provide information for assessing economic performances and financial risk. The cases were evaluated by a Techman Engineering Ltd. panel in the K-T format to identify the best alternatives and thus gain directional information on cases that appeared better than the base case and develop an understanding of the effects of size, technology and structure.

The K-T evaluation was subsequently repeated by the Concept Development Team. Their analysis confirmed the results of the Techman Engineering Ltd. evaluation.

As part of the design work for the selected cases, Techman Engineering Ltd. developed a modular mining scheme based on a short-haul, mobile equipment concept which appears particularly attractive for smaller plants or staged developments.

In addition to the case selection and evaluation, Techman Engineering Ltd. developed a description of a mega-project, as required by one of the sub-objectives of the study. This description includes a listing of all of the significant characterizing parameters of a mega-project, quantified where possible and relevant, to motivate an understanding of the nature of the "traditional" approach to tarsands development.

Based on the results of the Stage I work, as summarized in the "Conclusions" section of this report, Techman Engineering Ltd. has prepared "Recommendations" outlining the objectives and a detailed plan for executing the second stage of the study, without which the full benefits of the study will not be realized.

The Conclusions and Recommendations, including the Stage II work plan, were reviewed by the Concept Development Team.

Additional Stage I work, which will remain to be done after the submission of this report, includes the presentation of results to audiences selected by the Department of Energy, Mines and Resources.

5.0 REPORT CONTENTS

The report is presented in three volumes, the contents of which are outlined below:

VOLUME I - TEXT MATERIAL

- 1.0 INTRODUCTION
  - 1.1 Study Objectives
  - 1.2 Background Information

- 2.0 STUDY APPROACH
  - 2.1 Introduction
  - 2.2 Concept Development Team
  - 2.3 Techman Engineering Ltd.

- 3.0 MEGA-PROJECT DESCRIPTION
  - 3.1 Introduction
  - 3.2 Facilities and Process Description
  - 3.3 Characterization Parameters

- 4.0 ALTERNATE SCHEMES
  - 4.1 Introduction
  - 4.2 Selection of Cases for Analysis
  - 4.3 Case Descriptions
  - 4.4 Analysis of Selected Schemes

- 5.0 CONCLUSIONS
  - 5.1 Introduction
  - 5.2 Size
  - 5.3 Technology
  - 5.4 Ownership and Structure

- 6.0 RECOMMENDATIONS
  - 6.1 Introduction
  - 6.2 Work Statement for Stage II
  - 6.3 Stage II Schedule

- References
- Glossary of Terms

VOLUME II

APPENDIX A - MINUTES OF THE CONCEPT DEVELOPMENT TEAM MEETINGS (OCTOBER 1982)

APPENDIX B - MINUTES OF THE CONCEPT DEVELOPMENT TEAM MEETINGS (DECEMBER 1982)

Volume III

APPENDIX C - MINING SCHEMES

APPENDIX D - EXTRACTION SCHEMES

APPENDIX E - UPGRADING SCHEMES

APPENDIX F - UTILITIES